LOAN DOCUMENT

PHOTOGRAPH THIS SHEET

DTIC ACCESSION NUMBER

LEVEL

INVENTORY 1

PB-285 779

DOCUMENT IDENTIFICATION

Jul 78

DISTRIBUTION STATEMENT A
Approved for Public Release
Distribution Unlimited

DISTRIBUTION STATEMENT

ACCESSION FOR
NTIS GRA&I
DTIC TRAC
UNANNOUNCED
JUSTIFICATION

BY

DISTRIBUTION/

AVAILABILITY CODES

DISTRIBUTION	AVAILABILITY AND/OR SPECIAL	
A-1		

DISTRIBUTION STAMP

DATE ACCESSIONED

DATE RETURNED

19990507 160

DATE RECEIVED IN DTIC

REGISTERED OR CERTIFIED NUMBER

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-FDAC

DTIC FORM 70A JUN 90

DOCUMENT PROCESSING SHEET

PREVIOUS EDITIONS MAY BE USED UNTIL STOCK IS EXHAUSTED.

LOAN DOCUMENT

HANDLE WITH CARE

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-285 779

The Use of Numerical Control Technology in Small Metalworking Plants

IIT Research Inst, Chicago, IL

Prepared for

National Center for Productivity and Quality of Working Life, Washington, DC

Jul 78

IIT Research Institute
Engineering Division
10 West 35th Street
Chicago, Illinois 60616

THE USE OF NUMERICAL CONTROL TECHNOLOGY IN SMALL METALWORKING PLANTS

Final Report - J6425

Prepared for

National Center for Productivity
and Quality of Working Life
2000 M Street, N.W.
Washington, D.C. 20036

By

George P. Putnam

July 19, 1978

BIBLIOGRAPHIC DATA SHEET	1. Report No.	2.	3. Recipient's Accession No. PB285779

4. Title and Subtitle

The Use of Nmmerical Control Technology in Small Metalworking Plants

5. Report Date: July 1978

6.

7. Author(s): George P. Putnam

8. Performing Organization Rept. No.

9. Performing Organization Name and Address

IIT Research Institute
Engineering Division
10 West 35th Street
Chicago, Ill 60616

10. Project/Task/Work Unit No.

11. Contract/Grant No.: NP7AC014

12. Sponsoring Organization Name and Address

National Center for Productivity and Quality of Working Life, 2000 M St., N.W., Washington, D.C.

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstracts

Numerical control of metalworking machines and flexible manufacturing systems could help raise emtalworking productivity. These ~~mxkxixwxxkixgx~~ systems permit automation of small-lot production and more variety in design than mass production allows. Their information requirements are much greater, however, and progress in adopting them has been slower than anticipated. This report identifies three major barriers -- aside from makket factors -- thtat have prevented more small firms from adopting numerical control ktechniques: The inability of small manufacturers to test objectively the new techniques on their own products, independently from the vendor; the difficulty of measuring the indirect benefits of automated equipment, such as the value of flexibility to a small firm; and the fear of too much costly downtime, because complex machinery cannot be repaired quickly.

17. Key Words and Document Analysis. 17a. Descriptors

Numerical control, metalworking, productivity, productivity improvement, automation, small-lot production, small manufacturers

17b. Identifiers/Open-Ended Terms

17c. COSATI Field/Group

18. Availability Statement

Unlimited distribution

19. Security Class (This Report) UNCLASSIFIED

20. Security Class (This Page) UNCLASSIFIED

22. Price A04 - A01

FOREWORD

This document, prepared by IIT Research Institute is submitted in partial fulfillment of the requirements of the National Center for Productivity and Quality of Working Life Contract No. NP7AC014. It serves to report the methodology, findings and recommendations related to a survey of small and medium sized metalworking plants relative to the reasons for their not using Numerical Control (N/C) technology in their operations.

The 10 month effort covered by this report began in October 1977 and ended in July 1978. The study was monitored by Mr. Charles H. Kimzey of the National Center for Productivity and Quality of Working Life.

IITRI is pleased to have had the opportunity to conduct and document this study. We believe that this effort will contribute significantly to improving the United States national productivity by indicating a positive approach to increasing the diffusion N/C technology in small and medium sized United States metalworking plants.

Respectfully submitted,

George P. Putnam

George P. Putnam
Manufacturing Technology Advisor

Approved

K. E. McKee

K. E. McKee
Director
Manufacturing Productivity Center

TABLE OF CONTENTS

LIST OF ILLUSTRATIONS

1. EXECUTIVE SUMMARY

At a time when the United States' rate of productivity growth is the lowest in the industrialized world, a course of action is urgently needed to improve both our national productivity and its rate of growth.

Several groups - the General Accounting Office, Professional Societies, the National Machine Tool Builders Association, The National Center for Productivity and Quality of Working Life are showing increasing concern for the fact that technology developed in the United States is being diffused more effectively in some foreign countries than it is in the United States.

Computer Aided Manufacturing (CAM) is well recognized as the type of advanced manufacturing technology that needs to be applied by small and medium sized metalworking plants to improve our productivity. Most particularly, this applies to small and medium sized factories using Numerical/Control (N/C) as the core of CAM.

To determine the major barriers preventing N/C technology from being used by small and medium sized firms, this survey was conducted. In addition to identifying these barriers proposed solutions to eliminating these barriers are recommended.

Questionnaires from 366 non N/C users and 146 N/C users were analyzed to determine these barriers and proposed solutions. The significant survey findings are:

- Most plants (72 percent) that do not use N/C have not made a formal evaluation of N/C and what it can do for them.
- Most non N/C users feel that the cost of N/C equipment is too high.
- Non N/C users would like to know how to make a cost justification analysis of N/C.
- Non N/C users feel a definite need to learn more about N/C - and they prefer to learn about N/C using "hands-on" methods in such areas as programming, operating and maintaining N/C equipment.

- Before they acquire N/C, non N/C users feel that people in their own organization will have to make cost justification studies. This group strongly feels that appropriate tax incentives would stimulate them to use N/C.

- Over 40 percent of the non N/C users have an intuitive feeling that they will be using N/C within 5 years.

Based on these findings and information supplied by N/C users the survey also:

- led to the development of a quick and simple test that can be made by a non N/C user to determine he is a potential candidate for N/C

- shows that there are at least 7,500 small and medium sized plants (less than 200 employees) who are not now using N/C but should be using N/C.

The above findings and conclusion lead to two major recommendations to help diffuse N/C technology among small and medium sized metalworking plants:

- tax incentives to encourage these plants to take the risks involved in being innovative

- developing the concept of the N/C Center here in the United States. Other countries-even developing-countries have developed this concept. Such a center would be administered by an impartial body with no special interest in selling specific brands of N/C technology. The center would basically consist of a staff of N/C technologists and a variety of N/C machine tools and related hardware and software. This would permit the "hands-on" type of training in managing, justifying, programming, operating and maintaining N/C technology that small and medium sized firms need and want.

2. BACKGROUND

In June 1976 the United States General Accounting Office (GAO) released a most significant report, "Manufacturing Technology-A Changing Challenge to Improved Productivity" - LCD-75-436. For those who have not read this GAO report, the investment in time and effort would be most worthwhile.

This document focuses on the productivity of United States discrete parts batch manufacturing in general and the application of Computer Aided Manufacturing (CAM) technology to this very important segment of our national manufacturing activity. Thirty-five percent of the nation's manufacturing firms fall into the discrete parts batch manufacturing category.

This report cited some very alarming facts, among them being

- Since World War II the productivity growth rate of the United States is the lowest in the industrialized world
- CAM - especially numerically controlled (N/C) machining is an advanced manufacturing technology which would appear to be capable of impacting significantly on manufacturing productivity
- The application of this technology is not progressing fast enough to sustain our economic way of life
- Without added impetus this technology does now show promise of diffusing to small or medium sized firms.

Based on these findings, this study was conducted to determine two primary objectives:

- the reasons for small metalworking establishments not using N/C,
- what could be done to help identify and overcome the barriers to these establishments not using N/C.

3. SURVEY METHODOLOGY

In order to achieve the study objectives, a questionnaire was designed to elicit a response from small and medium sized manufacturing organizations. The questionnaire was targeted primarily at organizations who are not N/C users. However, it was recognized that some questionnaires would find their way to N/C users. Consequently, some questions were directed to N/C users as well.

Once the questionnaire was designed it was mailed to a test group of 100 potential respondents. A total of 18 responses were received.

A sample of these respondents were interviewed by telephone to determine the clarity of the questions and length of time it took to complete the questionnaire. The general consensus was that the questions were clear and understandable. All respondents questioned indicated that the questionnaire required only 20 minutes of their time to complete due to the "multiple-choice" nature of the questions.

Minor changes were made to the questionnaire to facilitate keypunching for machine processing and to place more emphasis on the respondent to indicate what needed to be done before he would use N/C in his plant.

The final version of the questionnaire consisted of 46 questions, all of which could be answered on a "yes/no" or "multiple-choice" basis so that the information could be machine tabulated. Subdivided into major categories, the responses to the questions described or indicated:

- the plant being surveyed in terms of number of employees, annual sales, number of machine tools, age of machine tools, computer applications, etc.
- the N/C terminology with which the respondent was familiar

- the plant's manufacturing environment in terms of parts complexity, tolerances, feed and speed changes, number of setups, parts design change frequency, jigs and fixtures, etc.
- the sources of the respondent's N/C information and knowledge
- the impediments to applying N/C
- the reasons for not using N/C
- the preferred method for learning about N/C
- what would have to be done before the plant would use N/C
- a forecast of the use of N/C equipment in N/C users and non N/C users facilities
- the reasons N/C users acquired N/C equipment

A copy of this questionnaire together with the covering letter of instructions for its completion appears in the appendix to this report.

Machine and Tool Blue Book (a Hitchcock Publication) contributed to the survey by printing and mailing the questionnaires to individuals on their mailing list. To be sure the sample selected was both random and representative, Blue Book adhered to the following procedures:

- Only one name (an owner or manufacturing manager) at each selected plant location received a questionnaire.
- Plants that indicated purchases of N/C equipment or supplies were excluded. This did not completely eliminate N/C users from responding, but it did produce a response population composed primarily of non N/C users - the target population.
- Plants were selected from the 13 key states which account for 73 percent of United States manufacturing establishments. Each of these states was represented in the survey to a degree proportional to the number of manufacturing establishments within its borders.

- An attempt was made to exclude plants employing more than 200 persons.
- A random number generator was used to select the questionnaire recipients within the designed constraints.
- In order to avoid a disproportinate response from very small and very large companies, an effort was made to mail 60 percent of the questionnaires to plants with an employment level between 20 and 100 people.

The mailing of 7,500 questionnaires with a postage paid return envelope was distributed among the 13 key states as follows:

California	976
Illinois	880
New York	852
Ohio	810
Michigan	761
Pennsylvania	656
New Jersey	535
Texas	436
Massachusetts	413
Wisconsin	334
Indiana	329
Connecticut	310
Minnesota	208
Total	7,500

As questionnaires were returned, the responses were key-punched on 2 cards for each questionnaire returned.

Eight weeks was allowed for questionnaires to be returned. After this time had elapsed, the data which were punched in cards were statistically processed using the Statistical Analysis System (SAS) software package developed by the SAS Institute, Raleigh, North Carolina.

After the results were tabulated and reviewed, a group of approximately 25 respondents were contacted by telephone to obtain

- their general reaction to the study
- a more detailed description of the type of analysis they make prior to acquiring capital equipment
- their attitude towards the concept of an N/C Center (discussed in the Recommendations Section of this report).

4. SURVEY RESULTS

4.1 General

A total of 540 responses were received from individuals to whom the questionnaire was mailed. Twenty-eight responses could not be used because of the fact that only a very few of the questions were answered or no questions were answered. While the response of 7.2 percent, was short of that which was expected, it is considered sufficiently reliable from a statistical point of view so that it forms a basis for reaching sound conclusions.

Of the 512 usable responses, 366 were from non N/C users and 148 were from N/C users. The questionnaires for each of these categories together with summarized responses for each question appear in the Appendix.

Within each category of questions the responses were summarized for non N/C users and N/C users separately. Although the survey's principal target was the non N/C user, the N/C user data were tabulated and analyzed since they were available. In many instances the comparison of the two groups can prove helpful in determining courses of action designed to improve the diffusion of N/C technology into those plants to which it appears applicable.

4.2 Plant Description and Environment

Typical profiles of the plants participating in the survey are shown in Figure 1. In comparing the N/C user to the non N/C user it can be seen that the N/C user more frequently

- has a greater number of employees
- has greater design control over the parts produced. In other words they design and manufacture their own parts instead of producing designs which have been supplied to them by customers
- is a division of a larger corporation
- has more machine tools

TYPICAL PROFILES OF PLANTS PARTICIPATING IN THE SURVEY

	NON N/C USER	N/C USER
• NUMBER OF EMPLOYEES	50-100	100-200
• ANNUAL SALES (MILLIONS OF $)	2-5	2-5
• DESIGN CONTROL OF PARTS (%)	64	72
• DIVISION OF A CORPORATION (%)	36	49
• NUMBER OF MACHINE TOOLS	10-25	25-50
• AGE CATEGORY OF MACHINE TOOLS (YRS)	10-15	10-15
• TOTAL MACHINE TOOL MAINTENANCE PERFORMED "IN HOUSE" (%)	40	23
• COMPUTER OR TERMINAL ON PREMISES (%)	32	74
• USE OF COMPUTER SERVICE BUREAU (%)	30	48
• NO MANUFACTURING COMPUTER APPLICATIONS (%)	52	16

Figure 1

- performs a smaller percentage of the required machine maintenance "in-house" and therefore has a greater percentage performed by outside contractors
- makes greater use of computer power

The manufacturing environment for the participants is shown in Figure 2.

One would expect N/C users to produce parts with tighter tolerances, more required changes in feeds and speeds and a greater frequency of design changes.

In the areas of typical setup time per part, number of set-ups per part, and the requirements for special jigs and fixtures, a difference is noted but more data (such as previous conditions) would need to be known before implying any reasons for the difference. For example, it might mean that non N/C users simply produce simpler parts which would make the economic justification of N/C more difficult.

4.3 Sources of Information

The survey requested respondents to indicate the sources from which they received information about N/C. Figure 3 represents the distribution of the responses.

Both the N/C users and non N/C users followed the same general pattern with trade journals, product literature and tool shows being the most popular sources. As might be expected, N/C users tend to be more heavily involved in acquiring N/C knowledge than non N/C users.

While Figure 3 indicates the most popular sources of knowledge, it does not indicate the sources of knowledge which have the most impact. Figure 4 provides this information.

Courses and Seminars, Practical Experience, and Tool Shows are the sources of N/C knowledge with the most impact on the

MANUFACTURING ENVIRONMENT

CHARACTERISTIC	NON N/C USERS	N/C USERS
PERCENTAGE OF PLANTS PRODUCING COMPLEX PARTS	10-30	9-36
TYPICAL SETUP TIME FOR A PART	Under 1 hr.	1-3 Hrs.
TYPICAL LOT SIZE	50-100	50-100
PERCENTAGE OF PLANTS WITH SIGNIFICANT AMOUNT OF TIGHT TOLERANCE PRODUCTION	19	24
PERCENTAGE OF PLANTS WITH GREATER THAN 3 FEED AND SPEED CHANGES PER SETUP	16	48
PERCENTAGE OF PLANTS WITH GREATER THAN 5 DESIGN CHANGES PER PART PER YEAR	5	9
PERCENTAGE OF PLANTS IN WHICH MORE THAN 25% OF THE PARTS CAN BE GROUPED IN FAMILIES	44	49
PERCENTAGE OF PLANTS IN WHICH THE AVERAGE NUMBER OF SETUPS PER PART EXCEEDS 6	17	24
PERCENTAGE OF PLANTS IN WHICH OVER 50% OF THE PARTS REQUIRE SPECIAL JIGS AND FIXTURES	19	26
PERCENTAGE OF PLANTS IN WHICH MORE THAN 25% OF THE PARTS HAVE NOT BEEN MACHINED BEFORE	29	19

Figure 2

SOURCES OF N/C INFORMATION

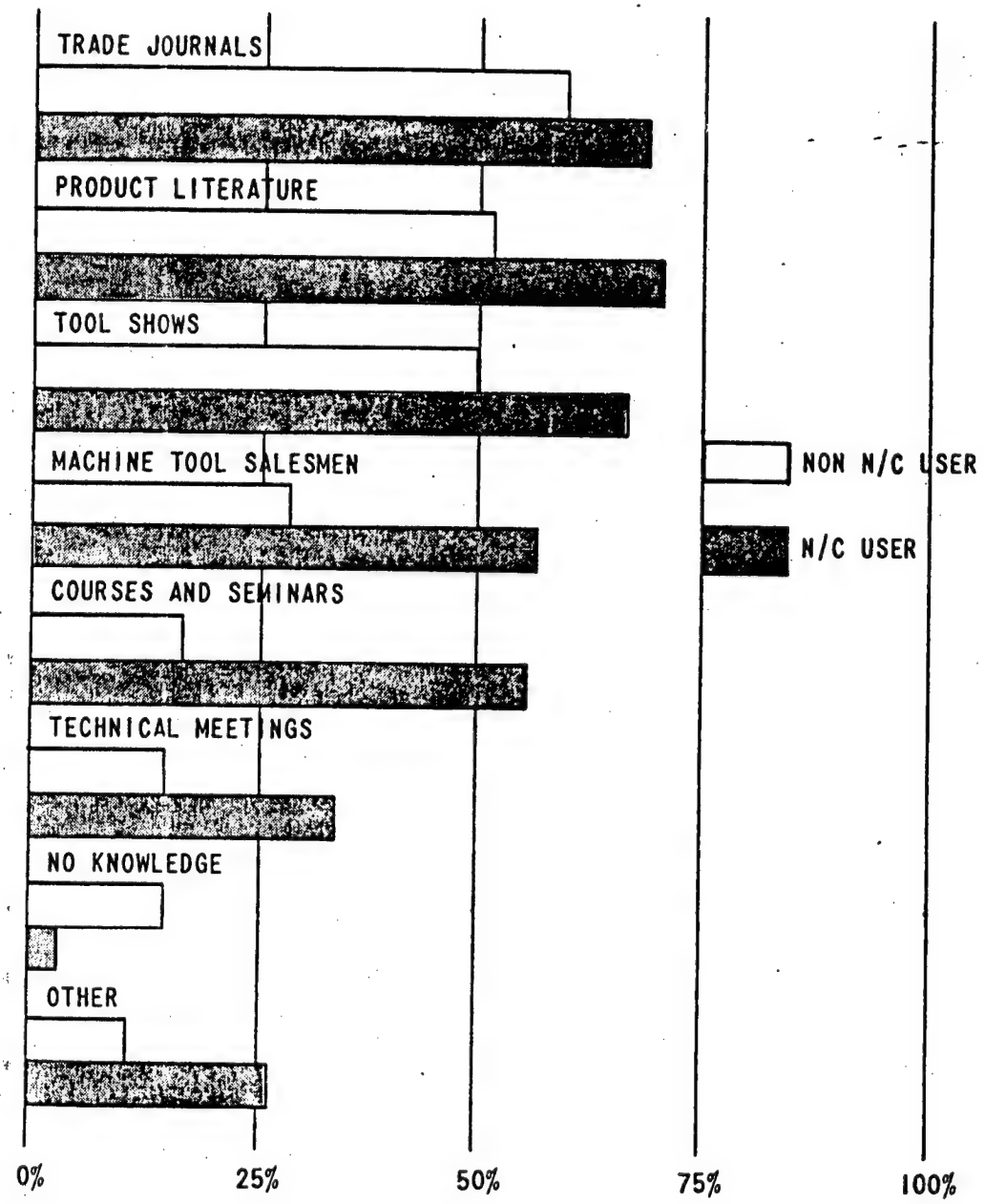


Figure 3

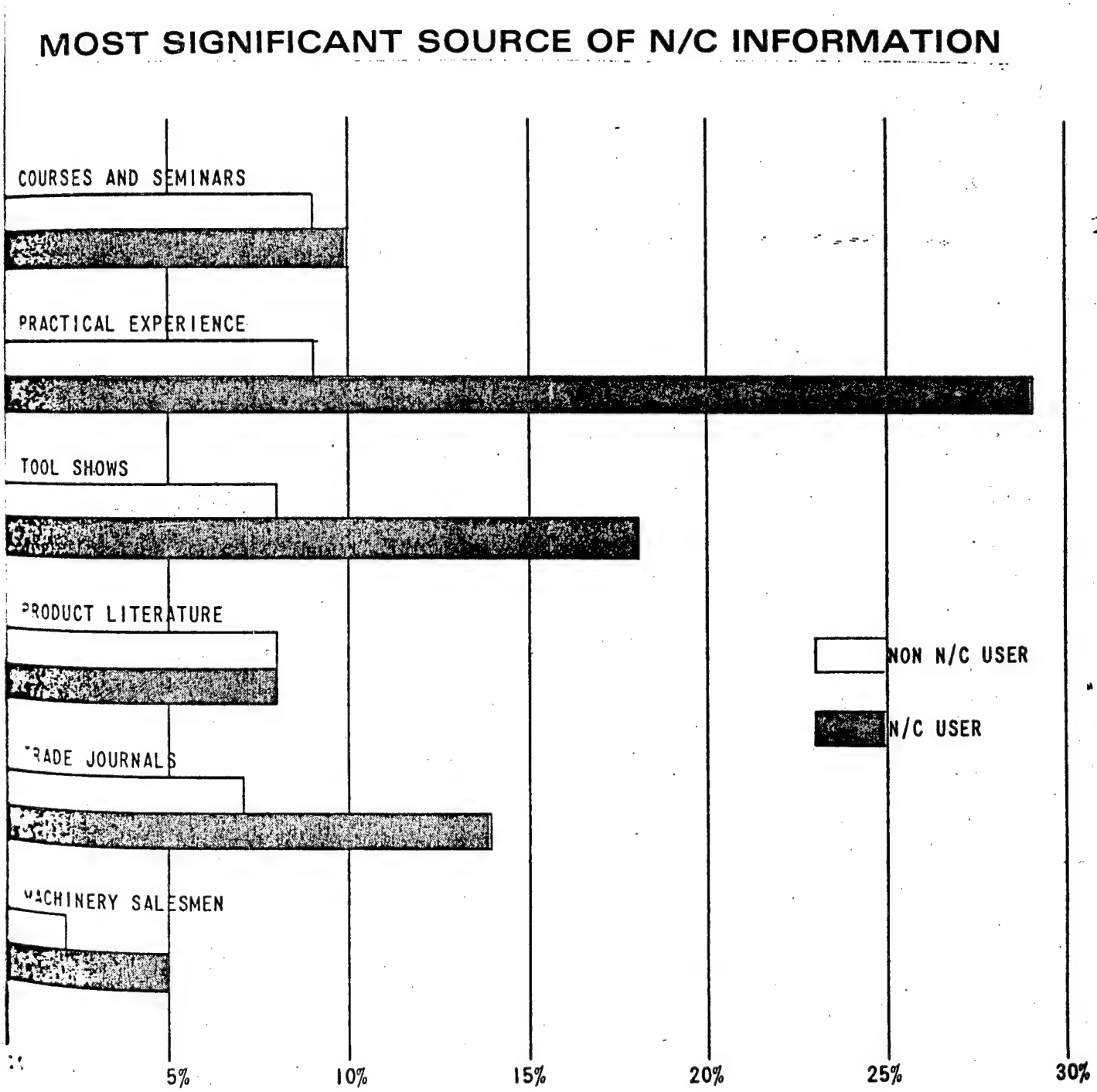

MOST SIGNIFICANT SOURCE OF N/C INFORMATION
COURSES AND SEMINARS
PRACTICAL EXPERIENCE
TOOL SHOWS
PRODUCT LITERATURE
TRADE JOURNALS
MACHINERY SALESMEN
NON N/C USER
N/C USER
5%
10%
15%
20%
25%
30%

Figure 4

learner. These sources, however, are more difficult to access since they require more of an investment in terms of time and money.

It is interesting to note that 70 percent of the non N/C users stated that they were generally familiar with the capability and applicability of N/C, while only 5 percent of this group stated that they thoroughly understood N/C. For the N/C users the picture is different in that 35 percent of the respondents felt they thoroughly understood N/C. Particular significance is attached to this information since it reflects the response given by general managers.

4.4 Impediments to N/C

In this area of the questionnaire only the replies from non N/C users were considered. Seventy-two percent of this group have not made a formal evaluation of N/C. Among this group:

- 18 percent feel N/C is applicable to their operations
- 52 percent feel N/C is not applicable
- 30 percent are unsure and need more information

Of the 28 percent who have formally evaluated N/C

- 40 percent feel N/C is applicable to their operations
- 52 percent feel N/C is not applicable
- 8 percent are unsure and need more information

Figure 5 lists the reasons given by non N/C users for the nonapplicability of N/C. Note that excessive cost of N/C ranks high while risk as a deterrent is the most infrequent answer given.

Figure 6 depicts the kinds of additional information both N/C users and non N/C users would consider helpful in evaluating N/C. Here it can be seen that users and nonusers differ somewhat in their priorities.

Both groups would clearly like more information on cost justification. N/C users, because of their experience, are more

REASONS FOR NON APPLICABILITY OF NUMERICAL CONTROL

(NON N/C USERS ONLY)

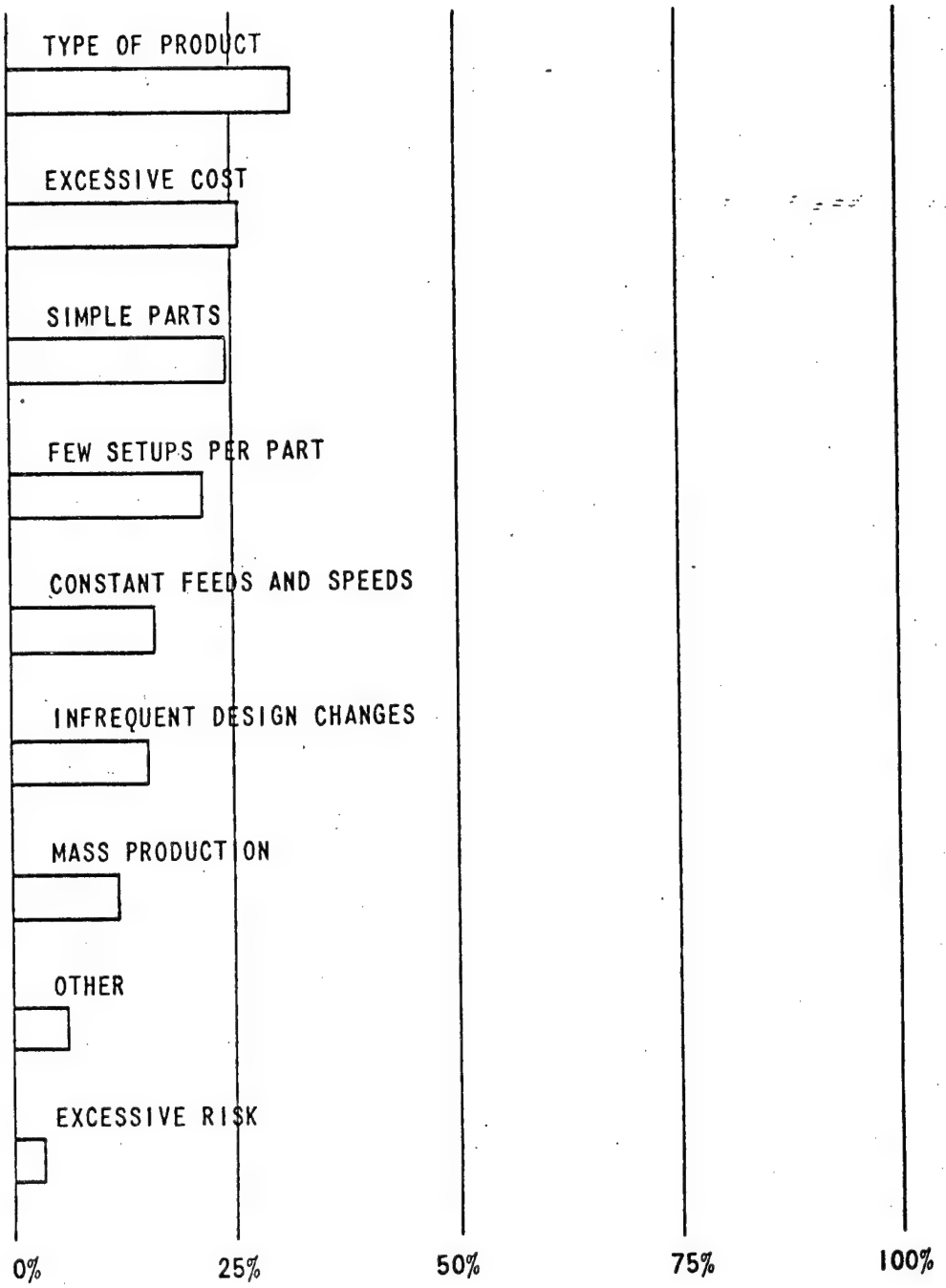


Figure 5

N/C INFORMATION CONSIDERED HELPFUL

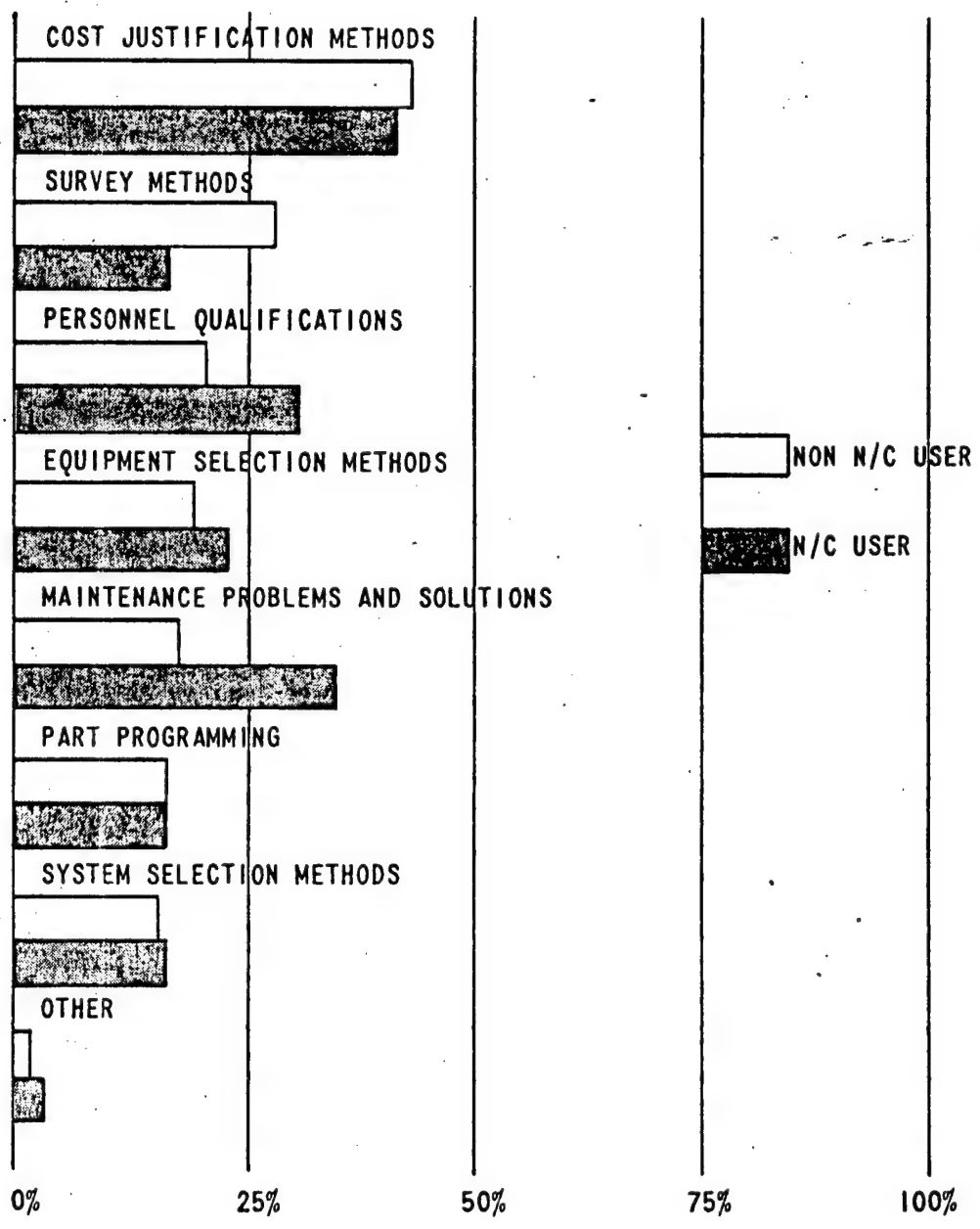


Figure 6

concerned with maintenance while non N/C users are more concerned about methods of surveying their plant to determine whether or not N/C is applicable.

Reasons Given for Not Using N/C

Here, again, the survey is concerned only with non N/C users and the reasons that past and existing efforts failed to convince them to use N/C technology. Figure 7 is a representation of the response pattern to the series of questions related to this subject. The two principal reasons cited for not using N/C is that an analysis showed that N/C was not applicable plus the return on investment was poor. The remainder of the reasons given represent anticipated fears and action not taken.

Preferred Means of Becoming Familiar With N/C

In this segment of the questionnaire recipients indicated the preferred techniques by which they wished to learn about N/C. In general there was an overwhelming preference for "hands-on" methods of learning. This especially true of the N/C user. Figure 8 shows the rank order preference of the respondents.

Barriers to Using N/C

The survey asked those questioned to cite events which would have to take place before non N/C users began to use N/C and N/C users significantly increased their use of this technology. An examination of Figure 9 shows the N/C user and non N/C user patterns to be quite similar with the exception of the area relating to tax incentives. N/C users feel this to be much more of a factor than non N/C users. User justification studies are of paramount importance. This means that the plant considering the acquisition of N/C equipment must develop the ability to make a sound justification study.

Forecasting N/C Usage

Figure 10 applies to non N/C users and indicates their opinion as to when they will acquire their first piece of N/C

REASONS GIVEN FOR NOT USING N/C
(NON N/C USERS ONLY)

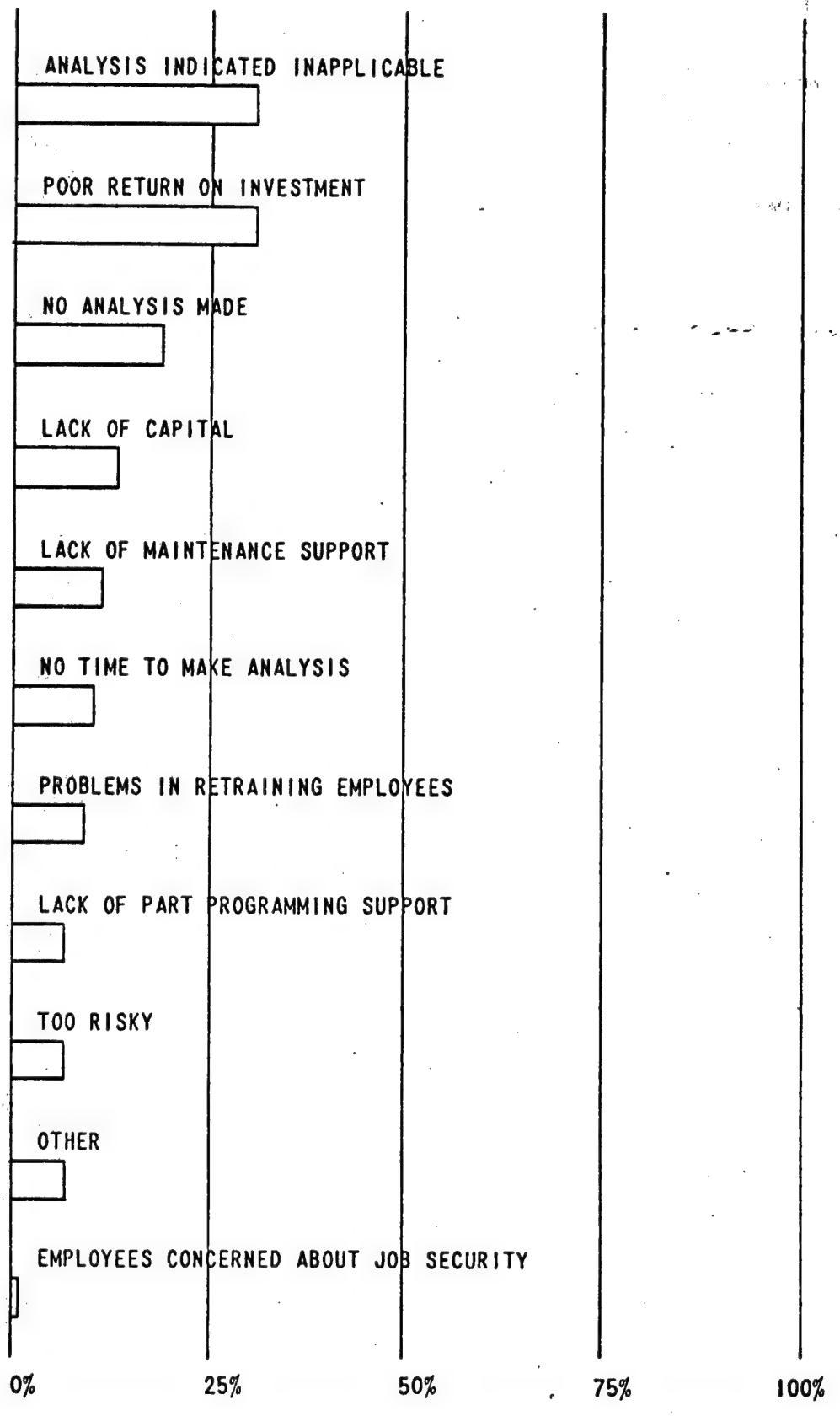
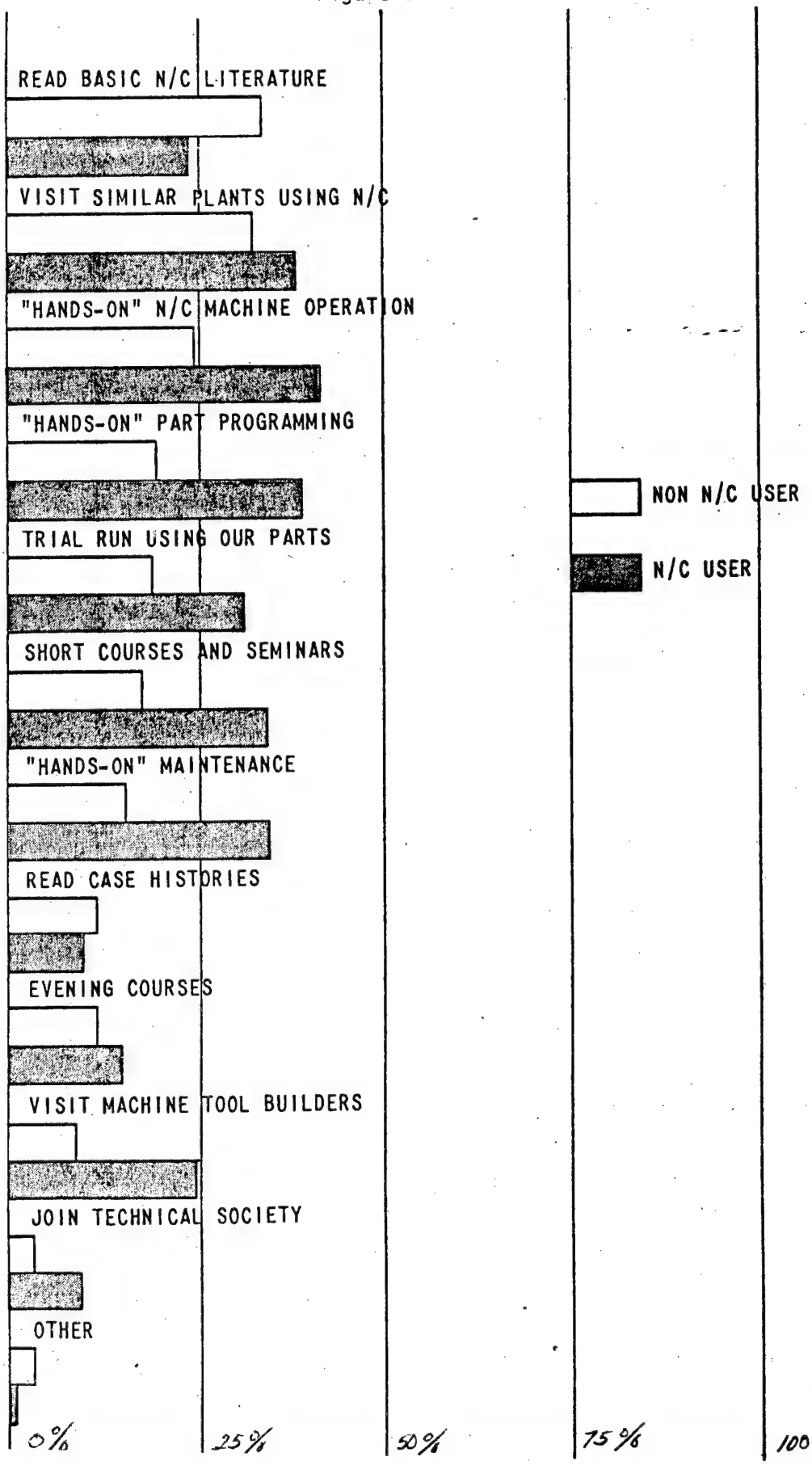


Figure 7

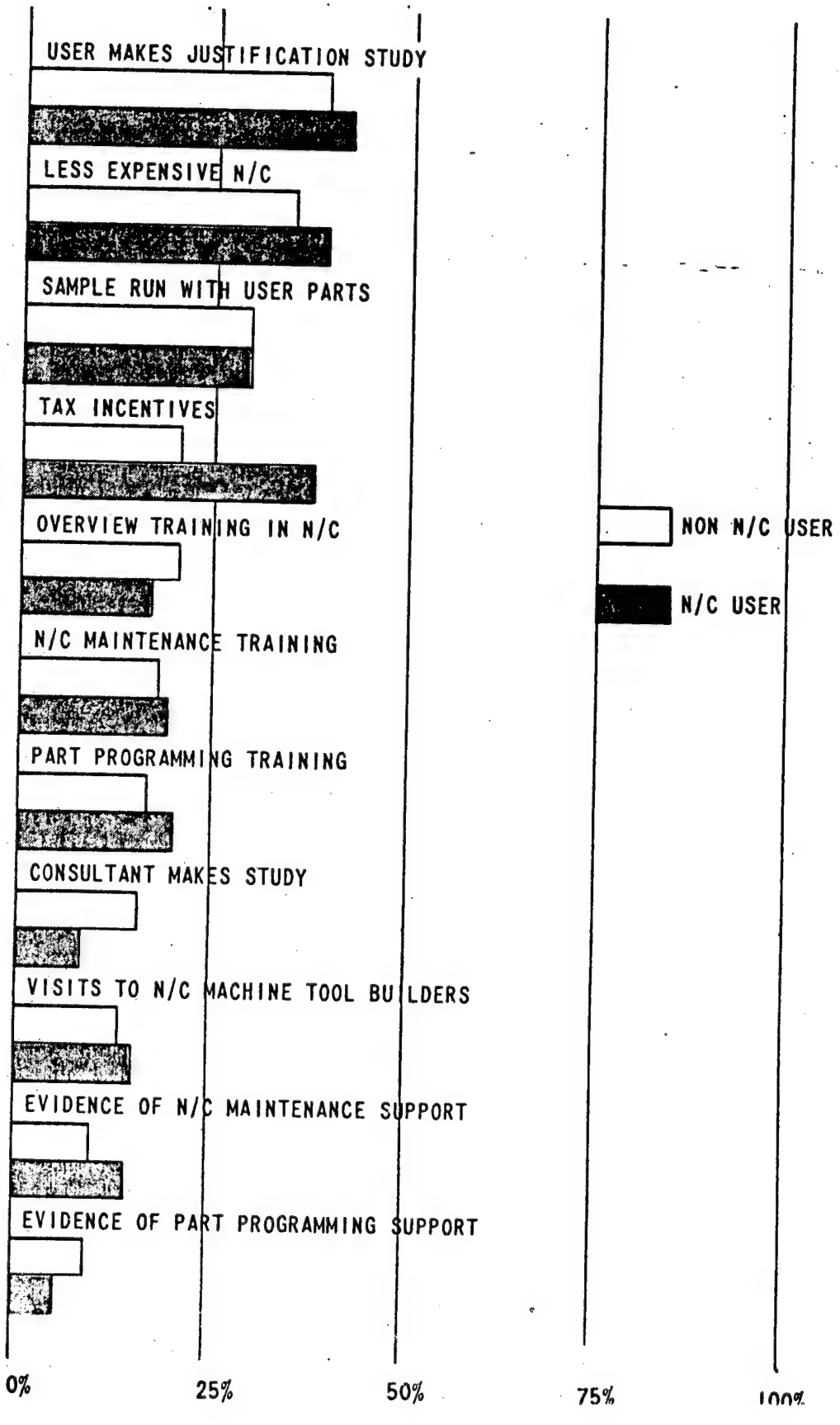
PREFERRED MEANS OF BECOMING FAMILIAR WITH N/C

Figure 9



BARRIERS TO USING N/C

Figure 9



TIME ESTIMATE WITHIN WHICH FIRST N/C MACHINE WILL BE ACQUIRED (NON N/C USERS ONLY)

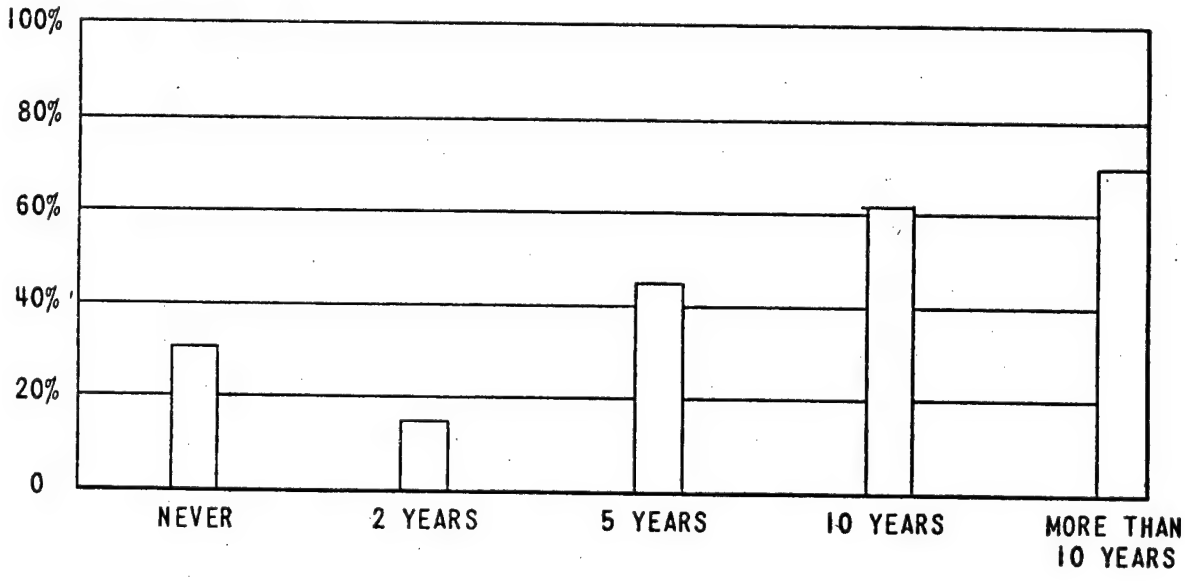


Figure 10

equipment. It is interesting to note that almost half of this group feel confident that they will be using N/C technology within the next 5 years. Thirty percent of this group feels that they will never acquire N/C.

Figure 11 applies to all respondents. It is impressive to note that 80 percent of the N/C users feel that at least 10 percent of their machines will be N/C within 10 years, while almost 35 percent of the non N/C users feel that at least 10 percent of their machines will be N/C within this same time period.

4.9 Reasons N/C Users Purchased N/C

According to Figure 12 the primary reasons N/C users purchased N/C equipment was to reduce the direct cost of manufacturing parts. But a significant number of them purchased N/C to reduce indirect costs such as lead time, production control and tooling costs.

4.10 Telephone Interviews

In the telephone interviews selected survey respondents indicated that their response to being surveyed was very positive. They are most anxious to read the summary article reporting the survey results in the September 1978 issue of Machine and Tool Blue Book.

The telephone interviews indicated that the plants involved have very informal systems for evaluating capital expenditures. These systems typically:

- Are intuitive - and based on a general "feeling" that the capital acquisition should be made.
- Most of this group that used numerical data on reaching a decision on whether or not to purchase capital equipment used the simple "payback" method. This method involves dividing the cost of the equipment by the expected annual savings to determine the number of years it will take for the savings to "pay" for the equipment.

TIME ESTIMATE WITHIN WHICH 10% OF PLANT'S MACHINES WILL BE N/C

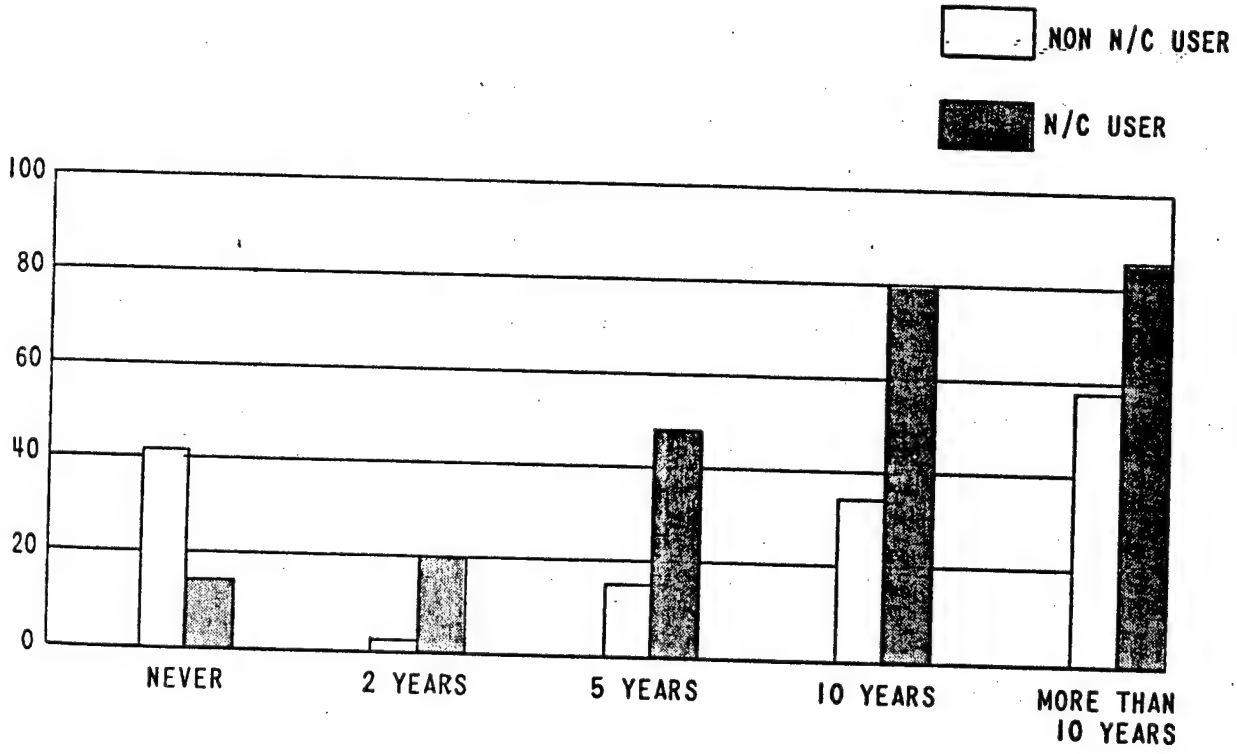


Figure 11

REASONS FOR PURCHASING N/C
(N/C USERS ONLY)

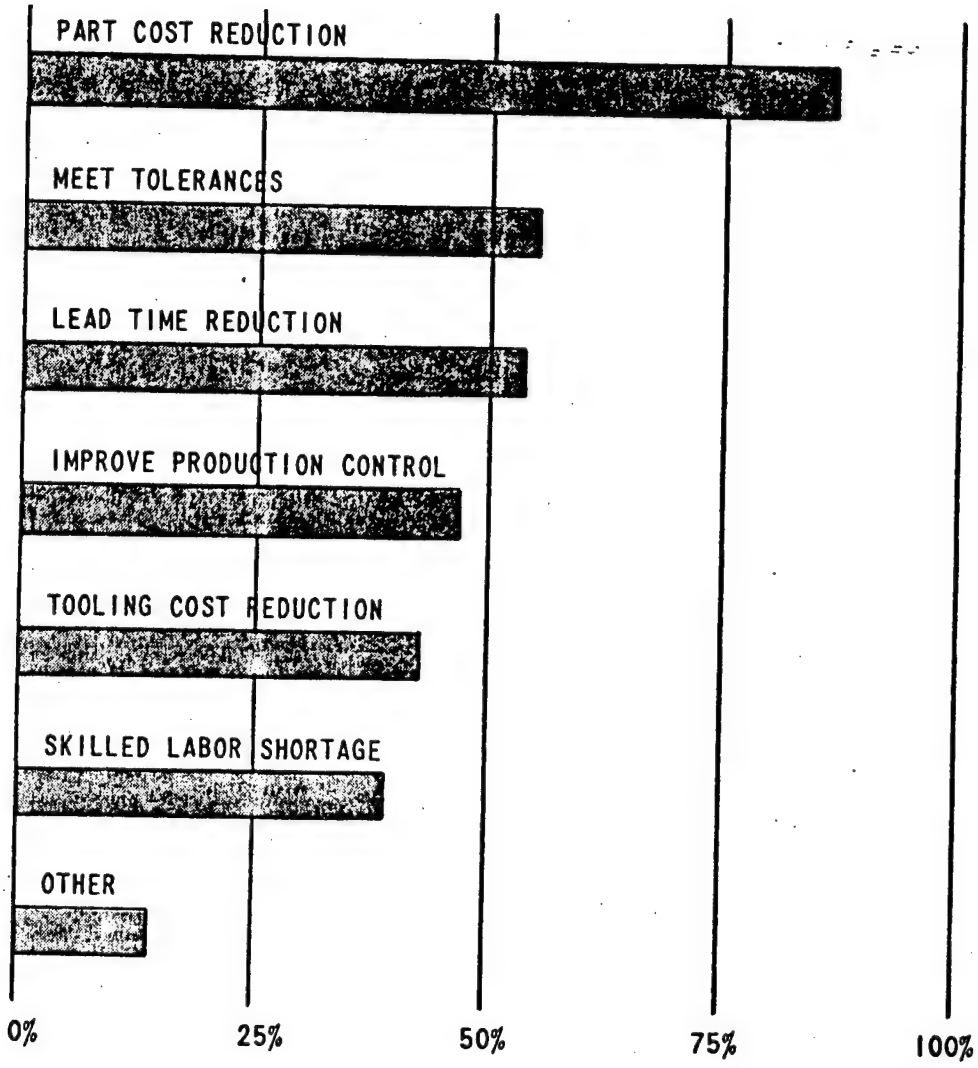


Figure 12

- All of those contacted were enthusiastic about the idea of the N/C Center concept discussed in Section 7 of this report. It was a most welcome prospect to them to contemplate a facility which would provide them with "hands-on" experience with N/C equipment and help them to determine its economic justification.

5. STATISTICAL RELIABILITY OF THE DATA

It is desirable to find a way to measure the accuracy of the sample percentages generated by the statistical data accumulated during this project. Assuming a normal distribution of the sample percentage about the true percentage of the population, the standard error of a sample percentage can be expressed as

$$SE = 100\sqrt{\frac{p(1-p)}{n}}$$

where

SE = standard error

p = the observed percentage expressed as a fraction (i.e., 5% would equal .05)

n = the sample size

this error will be maximum when p = .5 (50%)

In the case of this survey the maximum SE can be computed for

the N/C user population where n = 146

$$SE = 100\sqrt{\frac{.5(1-.5)}{146}} = 100\sqrt{\frac{.25}{146}} = 4.14\%$$

the non N/C user population where n = 366

$$SE = 100\sqrt{\frac{.5(1-.5)}{366}} = 100\sqrt{\frac{.25}{366}} = 2.61\%$$

the total population of N/C users and non N/C users where n = 512

$$SE = 100\sqrt{\frac{.5(1-.5)}{512}} = 100\sqrt{\frac{.25}{512}} = 2.21\%$$

Knowing these values of SE we can compute the maximum variation of sample percentages from true percentages with a confidence interval of 95% by applying the following formula

95% confidence limits = sample percentage $\pm$ 1.96 x SE

for N/C users

$$\pm 1.96 \times SE = \pm 1.96 \times 4.14 = \pm 8\%$$

for non N/C users

$$\pm 1.96 \times SE = \pm 1.96 \times 2.61 = \pm 5\%$$

for the total population

$$\pm 1.96 \times SE = \pm 1.96 \times 2.21 = \pm 4\%$$

This relationship - or method of calculating SE - applies when $p \geq \frac{10}{n}$

in this survey

for N/C users $\frac{10}{n} = \frac{10}{146} = .068$ or 6.8%

for N/C users $\frac{10}{n} = \frac{10}{366} = .027$ or 2.7%

for the total population $\frac{10}{n} = \frac{10}{512} = .020$ or 2.0%

In view of the above the following can be stated that 95% of the time the sample percentage will be a measure of the true population percentage

for the N/C user group within $\pm$ 8% when the percentage exceeds 6.8%
for the non N/C user group within $\pm$ 5% when the percentage exceeds 2.7%
for the total group within $\pm$ 4% when the percentage exceeds 2.0%

Remember these are the worst cases which occur when p = 50%

To realize the impact of this, consider the non N/C user answer to question 1-58, "Have you made a formal evaluation of the applicability of N/C to your operations"?

This question was answered positively (yes) by 28.4% of the non N/C users. The above general condition states that we can be 95% certain that between 23.4% and 33.4% of the total population has made such a formal evaluation.

If a more accurate estimate is required it is calculated as follows

$$SE = \sqrt{\frac{p(1-p)}{n}} = \sqrt{\frac{(.284)(.716)}{366}} = .024 \text{ or } 2.4\%$$

$$95\% \text{ confidence limits} = \pm 1.96 \times 2.4 = \pm 4.6$$

We can be 95% certain that between 23.8% and 33.0% made such an evaluation.

For the purposes of this study it is practical to use the wider limits instead of calculating limits for each percentage observed since the error will always be in the conservative direction.

6. MAJOR CONCLUSIONS

The survey produced several major findings which can be consolidated into four principal areas:

- A simple method for measuring the applicability of N/C to a given plant
- An indication of the potential applicability of N/C to those plants that are not presently using it
- The confidence that both N/C users and non N/C users have in the future applicability of N/C
- An indication of the preferences of non N/C users in learning about N/C and overcoming the barriers to applying it

Each of these areas will be discussed separately.

Measuring the Applicability of N/C

An excellent starting point for a non N/C user in determining whether or not N/C might be applicable to his operations would be to compare himself to an N/C user. In effect, Figure 13 makes this comparison for several key characteristics. Lists of principles relating manufacturing environment to N/C have been developed by many sources. Here is a partial list of some of the more significant principles.

N/C tends to be applicable to a given manufacturing plant when:

- a large proportion of the parts can be grouped into families
- speeds and feeds change often within a setup
- many parts have contours that can be identified by mathematical equations
- the lot sizes are small to medium
- part contours are comprised of other than lines and circles
- parts are geometrically complex

COMPARISON OF MANUFACTURING ENVIRONMENT
FOR SELECTED KEY ITEMS
N/C USERS VS NON N/C USERS

MANUFACTURING CHARACTERISTIC	PERCENT N/C USERS	PERCENT NON N/C USERS
More than 25% of parts can be grouped in families	49	44
More than 25% of parts require 3 or more speed/feed changes within a single setup	48	16
Parts with contours defined by mathematical equations	45	24
Typical lot size is less than 50 pieces	44	40
More than 25% of parts contain contours that are not lines and/or circles	36	29
More than 25% of parts contain compound angles	30	21
Average setup exceeds 3 hours	27	13
More than 25% of parts have dimensional tolerances less than .001"	24	19
Typical part design is changed more than 5 times per year	9	8

Figure 13

- setup times are large
- parts have tight dimensional tolerances
- part designs change frequently

Figure 13 quantitatively compares N/C users and non N/C users with respect to characteristics related to these general principles. As one would expect the N/C users appear to be more reflective of these principles than non N/C users. However, these figures are based on aggregated data. Some of the environments in the non N/C user plants are similar to the environments of the N/C users.

This is more effectively observed by examining Figure 14. This chart indicates the percentage of N/C users and non N/C users that possess a certain number or more of the key characteristics that point to the applicability of N/C. In this study the average N/C user's environment incorporates 3 of these characteristics within his environment.

While it is not represented here as a total analysis tool, it is recommended that if a non N/C user would like a quick indication of the applicability of N/C to his operation he can measure himself against the list of characteristics in Figure 13. If he possesses 3 or more of these characteristics it is quite probable that N/C is applicable to his operation. A more "in-depth" analysis by an N/C engineer, consultant, or manufacturing engineer would certainly be justified.

The Potential Applicability of N/C to Non N/C Users

An extrapolation of the data in Appendix I of the GAO report of 1976 (cited earlier) would lead to the conclusion that there are at least 22,700 plants with 200 or less employees that are non N/C users.

The survey being summarized here indicates (see Figure 14) that 33.3 percent of the non N/C users possess 3 or more of the environmental characteristics of N/C users.

COMPARISON OF N/C USERS AND NON N/C USERS
BASED ON PRESENCE OF KEY MANUFACTURING
CHARACTERISTICS

NUMBER OF KEY MANUFACTURING CHARACTERISTICS PRESENT IN THE PLANT	PERCENT	
	N/C USERS	NON N/C USERS
9	0	0
8 or more	0	0
7 or more	2.1	1.1
6 or more	6.2	1.9
5 or more	20.5	7.4
4 or more	36.9	16.4
3 or more	60.2	33.3
2 or more	84.2	61.5
1 or more	96.6	89.6
NONE	3.4	10.4

Figure 14

Coupling these data it would appear probable that there are at least 7,500 U.S. metalworking plants in the United States with fewer than 200 employees who should seriously consider the applicability of N/C to their operations.

Confidence in the Future

As one can see by examining Figures 10 and 11 a large proportion of non N/C users feel (intuitively or otherwise) that they should be acquiring N/C within the next 5 years. In fact almost 14 percent of this group feels that 10 percent of their machine tools will be N/C within 2-5 years. These data are consistent with the non N/C user response to a question asking if they had formally evaluated the applicability of N/C to their operations. Seventy-two percent of the respondents replied negatively to this question (the analyses made as shown in Figure 7 may have been cursory and informal).

This all adds up to the healthy conclusion that non N/C users are not hostile towards using N/C. On the contrary, they seem to be predisposed to using it. What is lacking is a sound analysis to indicate the feasibility (or nonfeasibility) of N/C to their operations.

Learning About N/C and Overcoming the Barriers To Its Use By Non N/C Users

Several of the Figures in this article, notably Figures 4, 6, 8 and 9 indicate a marked preference for obtaining "hands-on" experience as part of the procedure for evaluating N/C. As far as N/C users are concerned (see Figure 4) this is by far the type of learning experience that has the biggest impact. Figure 8 particularly reflects the desire for "hands-on" experience as a learning tool. Figure 9 shows that the user (or potential user) making a justification study represents the biggest barrier to using N/C.

There is certainly a financial connotation to some of the barriers to using N/C - notably the expense of N/C equipment

itself and a feeling that stronger tax incentives need to be put in place.

Several categories of training in various aspects of N/C-management, maintenance, programming, etc. - are a matter of concern in removing the barriers to using N/C.

7. RECOMMENDATIONS

It is always difficult to project what will happen in the future. It is a less difficult task to speculate on what the future course of events should be.

Basically, the study reported in these pages supports and amplifies the GAO study of 2 years ago. The conditions which exist seem abundantly clear:

- Our N/C technology in the United States is as good (or better) as can be found anywhere in the world.
- This type of technology properly applied and diffused among small and medium sized manufacturing plants can materially assist the rate of growth of United States productivity.
- The United States is not diffusing this technology as well as it should or as well as several of the countries in the industrial world.

Most assuredly one of the actions that should be taken to spur the acquisition of this technology by those to whom it is applicable, is to provide tax incentives to make the acquisition cost of N/C technology less expensive. In addition it would help if some sort of tax credit could be given to provide an incentive to begin the learning curve with all its special problems of operating, managing, programming, and maintaining this equipment. However, this aspect of the solution involves political action as well as economic action, the discussion of which is beyond the scope of this report.

But there is something that can be done to address the needs of the non N/C user community as it has articulated them.

As one observes foreign countries the cooperation among government, industry and academia it is noticeably different than that which exists in the United States. This cooperation is much more of an operating reality abroad and it produces some attendant benefits.

There is no reason that this policy and technique could not be applied in the United States. It would serve the national interest very effectively. The mechanism which could be developed for implementing this policy would be the establishment of an N/C Center managed and operated by an impartial group (such as a university or research institute); partially funded by suppliers of N/C technology and equipment and the Government; and used by small and medium sized firms to evaluate and become involved with N/C technology.

Such a center would have 3 principal functions:

1. Demonstrating the operation and capability of N/C hardware and software - a place where potential small and medium sized users can operate and program equipment on a "hands-on" basis under the guidance of technically competent and impartial personnel. This would include assistance in making sample runs with the potential user's drawings and material for machining parts as well as assistance in making an economic justification.

2. Training personnel in managing, operating, programming, and maintaining N/C equipment in courses and seminars.

3. Disseminating information - by maintaining a library of technical publications and a general awareness of sources of information so that a potential user may obtain information directly or indirectly on any facet of N/C technology about which he may inquire.

As a result of the survey the non N/C user problems and needs have been surfaced in an organized fashion. Viable courses of action to respond to these needs are available. Let's hope they can be implemented.

APPENDIX

IIT Research Institute
10 West 35 Street, Chicago, Illinois 60616
312/567-4000

February 27, 1978

This is an important questionnaire. The answers you supply will be used to help you, your industry, and your country. It is not merely a device to develop a list of plants to be contacted by salesmen. You are not required to identify yourself in any way unless you so desire.

Authoritative government surveys have determined that while the United States is a world leader in developing new manufacturing technology, it is not a world leader in applying it.

A case in point, Numerically Controlled (N/C) machine tools -- machine tools whose slides and spindles are controlled by punched tape or a signal coming directly from a computer.

Some large manufacturers are using N/C. But the number of small manufacturing concerns in the United States (compared to Europe and Japan) who use N/C is extremely small.

If United States manufacturing industry is to effectively compete on an international basis, we need to improve our manufacturing productivity. N/C is one way -- a significant way -- to improve productivity. If other countries can use it effectively, why can't we?

Do we need to improve the technology somehow? Do we need to make people like you more familiar with N/C? Its application? Its justification? Does N/C need to be modified in some way before you can use it?

To find the answers to these and related questions, IIT Research Institute under the sponsorship of the National Center for Productivity and Quality of Working Life, has prepared this questionnaire to determine: information that describes your plant; where you obtained your N/C knowledge; whether or not you would like to learn more about N/C; how you would like to learn about N/C; why you are not using N/C; what is preventing you from using N/C; what would need to be done before you would use N/C.

The questionnaire is easy to answer and should take no longer than 20 minutes.

We would like to follow up a sample of the questionnaires by telephone for more detailed information. If you would like to participate in this phase of the project, please list your telephone number after the last question. If you do not wish us to contact you by phone, leave this item blank.

At the end of the questionnaire on the reverse side of the paper, or on a separate piece of paper you may make any comments you wish -- particularly if you feel the questions did not bring out something you wanted to point out.

A summary of the answers to these questions together with an analysis of our findings will be published in a forthcoming issue of Machine and Tool Blue Book.

Please complete the questionnaire now while it is before you and return it to us in the postage free envelope provided.

Many thanks for your cooperation.

George P. Putnam
Manufacturing Technology Advisor

Encl.:

MANUFACTURING SHOP SURVEY

SUMMARY OF RESPONSES FROM 366 COMPANIES

PLANT DESCRIPTION

1.1. IN WHAT STATE IS YOUR PLANT LOCATED?

CA	13.1	MA	6.0	NY	10.1	TX	3.8
CT	3.3	MI	6.8	OH	10.4	WI	6.6
IL	14.5	MN	3.8	PA	10.1	Unidentified	1.1
IN	4.9	NJ	5.2	SC	0.3		

1.2. HOW MANY PEOPLE ARE EMPLOYED AT THIS LOCATION? (CIRCLE ONE)

1. UNDER 25 — 23.8
2. 25-50 — 24.9
3. 50-100 — 25.8
4. 100-200 — 16.7
5. OVER 200 — 8.7

1.3. WHAT IS THE APPROXIMATE ANNUAL SALES DOLLAR VALUE OF PRODUCT PRODUCED AT THIS LOCATION? (CIRCLE ONE)

1. UNDER 1 MILLION 30.7
2. 1-2 MILLION 19.0
3. 2-5 MILLION 26.4
4. 5-10 MILLION 13.3
5. 10-15 MILLION 6.3
6. OVER 15 MILLION 4.3

1.4. ARE MOST OF THE ITEMS MANUFACTURED AT THIS LOCATION DESIGNED BY YOUR COMPANY? 1. YES ☐ 64.0 2. NO ☐ 36.0

1.5. IS THIS PLANT A DIVISION OR SUBSIDIARY OF A CORPORATION OR ONE OF A GROUP OF PLANTS IN THE SAME COMPANY? 1. YES ☐ 36.4 2. NO ☐ 63.6

1.6. WHAT IS THE APPROXIMATE NUMBER OF MACHINE TOOLS AT THIS LOCATION? (CIRCLE ONE)

1. UNDER 10 — 20.0
2. 10-25 — 32.8
3. 25-50 — 27.2
4. 50-100 — 13.3
5. OVER 100 — 6.7

1.7. INTO WHAT AGE CATEGORY DO MOST OF THESE MACHINES FALL? (CIRCLE ONE)

1. UNDER 5 YRS. — 6.1
2. 5-10 YRS. — 23.4
3. 10-15 YRS. — 28.7
4. 15-20 YRS. — 23.9
5. OVER 20 YRS. — 17.8

1.8. WHAT PROPORTION OF MACHINE TOOL MAINTENANCE IS PERFORMED BY YOUR OWN EMPLOYEES? (CIRCLE ONE)

1. ALL — 40.3
2. 75%-100% — 46.1
3. 50%-75% — 7.2
4. 25%-50% — 3.0
5. 1-25% — 2.8
6. NONE — .6

1.9. IS THERE A COMPUTER OR COMPUTER TERMINAL IN YOUR PLANT? 1. YES ☐ 31.9 2. NO ☐ 68.1

1.10. DO YOU USE A COMPUTER OR DATA PROCESSING SERVICE BUREAU? 1. YES 29.9 2. NO 70.1

WHAT TYPES OF MANUFACTURING COMPUTER APPLICATIONS DO YOU HAVE? (CIRCLE ALL THAT APPLY)

1.11. NONE 52.2

1.12. PRODUCTION CONTROL 25.4

1.13. INVENTORY CONTROL 30.9

1.14. TIME STANDARDS 13.9

1.15. QUALITY CONTROL 3.3

1.16. ROUTING 7.7

1.17. OTHER 10.1

SPECIFY _____

N/C INFORMATION

DO YOU KNOW THE MEANINGS OF THE FOLLOWING TERMS?

1.18.	NUMERICAL CONTROL	1. YES ☐ 94.0	2. NO ☐		
1.19.	PART PROGRAMMING	1. YES ☐ 74.9	2. NO ☐		
1.20.	PUNCHED TAPE	1. YES ☐ 91.3	2. NO ☐		
1.21.	GROUP TECHNOLOGY	1. YES ☐ 34.2	2. NO ☐		
1.22.	CNC	1. YES ☐ 39.3	2. NO ☐		
1.23.	DNC	1. YES ☐ 30.1	2. NO ☐		
1.24.	RNC	1. YES ☐ 10.9	2. NO ☐		
1.25.	APT	1. YES ☐ 18.9	2. NO ☐		
1.26.	MULTI AXIS	1. YES ☐ 66.7	2. NO ☐		
1.27.	BILATERAL DRIVER	1. YES ☐ 22.7	2. NO ☐		
1.28.	MACHINE CONTROL	1. YES ☐ 64.2	2. NO ☐		
1.29.	LINEAR INTERPOLATION	1. YES ☐ 44.5	2. NO ☐		

MANUFACTURING ENVIRONMENT

1.30. DO MORE THAN 25% OF YOUR PARTS CONTAIN STRAIGHT LINES, CONCENTRIC CIRCLES AND HOLES?
1. YES ☐ 2. NO ☐
87.7

1.31. DO MORE THAN 25% OF YOUR PARTS CONTAIN COMPOUND ANGLES?
1. YES ☐ 2. NO ☐
21.0

1.32. DO MORE THAN 25% OF YOUR PARTS CONTAIN ECCENTRIC CIRCLES?
1. YES ☐ 2. NO ☐
9.8

1.33. DO MORE THAN 25% OF YOUR PARTS CONTAIN CONTOURS THAT ARE NOT STRAIGHT LINES OR CIRCLES?
1. YES ☐ 2. NO ☐
29.2

1.34. HOW LONG DOES THE AVERAGE JOB SET-UP TAKE IN YOUR PLANT? (CIRCLE ONE)
1. UNDER 1 HOUR 53.0 2. 1-3 HOURS 34.1 3. 3-5 HOURS 7.2 4. 5-8 HOURS 3.7 5. OVER 8 HOURS 2.0

1.35. WHAT IS THE MOST TYPICAL LOT SIZE IN YOUR PLANT? (CIRCLE ONE)
1. UNDER 10 PCS 25.1 3. 25-50 PCS 6.9 5. 100-500 PCS 22.0
2. 10-25 PCS 8.3 4. 50-100 PCS 14.3 6. OVER 500 PCS 23.4

1.36. DO MORE THAN 25% OF YOUR PARTS HAVE DIMENSIONS WITH TOLERANCES GREATER THAN ± .005''? 1. YES ☐ 2. NO ☐
55.7

1.37. DO MORE THAN 25% OF YOUR PARTS HAVE DIMENSIONS WITH TOLERANCES BETWEEN ± .001'' AND ± .005''? 1. YES ☐ 2. NO ☐
53.3

1.38. DO MORE THAN 25% OF YOUR PARTS HAVE DIMENSIONS WITH TOLERANCES LESS THAN .001?
1. YES ☐ 2. NO ☐
18.6

1.39. DO YOU PRODUCE PARTS WITH CONTOURS DEFINED BY MATHEMATICAL EQUATIONS? 1. YES ☐ 2. NO ☐
23.5

1.40. WITHIN A SINGLE SET-UP DO MORE THAN 25% OF YOUR PARTS REQUIRE MORE THAN 1 CHANGE IN FEED OR SPEED? 1. YES ☐ 2. NO ☐
36.1

1.41. WITHIN A SINGLE SET-UP DO MORE THAN 25% OF YOUR PARTS REQUIRE MORE THAN 3 CHANGES IN FEED OR SPEED? 1. YES ☐ 2. NO ☐
15.6

1.42. WITHIN A SINGLE SET-UP DO MORE THAN 25% OF YOUR PARTS REQUIRE MORE THAN 5 CHANGES IN FEED OR SPEED? 1. YES ☐ 5.2 2. NO ☐

1.43. HOW OFTEN IS THE DESIGN OF THE TYPICAL PART MANUFACTURED IN YOUR PLANT CHANGED? (CIRCLE ONE)
1. NEVER 32.9 3. 2-5 TIMES PER YEAR 20.5 5. OVER 10 TIMES PER YEAR 7.0
2. ONCE PER YEAR 39.0 4. 5-10 TIMES PER YEAR 0.6

1.44. WHAT PERCENTAGE OF THE PARTS MANUFACTURED IN YOUR PLANT CAN BE GROUPED INTO FAMILIES BECAUSE OF SIMILAR SHAPES AND PROCESSING? (CIRCLE ONE)
1. NONE 13.3 3. 10%-25% 26.0 5. OVER 50% 28.0
2. 1%-10% 17.1 4. 25%-50% 15.6

1.45. HOW MANY MACHINING ''SET-UPS'' DOES THE AVERAGE PART YOU MANUFACTURE REQUIRE? (CIRCLE ONE)
1. ONE 12.9 2. 2-5 69.9 3. 6-10 13.2 4. OVER 10 4.1

1-46. WHAT PERCENTAGE OF THE PARTS YOU MACHINE REQUIRE SPECIAL JIGS AND FIXTURES? (CIRCLE ONE)
1. NONE 6.3 2. 1%-10% 32.4 3. 10%-25% 22.6 4. 25%-50% 19.8 5. OVER 50% 18.9

1-47. WHAT PERCENTAGE OF THE PARTS ENTERING YOUR MACHINE SHOP ARE PARTS YOU HAVE NOT MACHINED BEFORE? (CIRCLE ONE)
1. NONE 10.5 2. 1%-10% 40.5 3. 10%-25% 21.3 4. 25%-50% 9.6 5. OVER 50% 18.1

SOURCE OF N/C INFORMATION

HOW DID YOU ACQUIRE YOUR KNOWLEDGE OF N/C? (CIRCLE ALL THAT APPLY)

1-48. NO KNOWLEDGE 15.3
1-49. COURSES & SEMINARS 15.8
1-50. TRADE JOURNALS 60.4
1-51. PRODUCT LITERATURE 51.9
1-52. MACHINERY SALESMEN 28.1
1-53. TOOL SHOWS 48.6
1-54. TECHNICAL MEETINGS 15.0
1-55. OTHER (SPECIFY) 10.9 (mostly practical experience)

1-56. WRITE DOWN THE NUMBER OF THE ANSWER 1-48 THROUGH 1-55 ABOVE THAT CONTRIBUTED MOST SIGNIFICANTLY TO YOUR KNOWLEDGE OF N/C. See Figure 4

1-57. WHICH OF THE FOLLOWING APPLIES TO YOU? (CIRCLE ONE)
1. UNFAMILIAR WITH N/C 25.6
2. GENERALLY UNDERSTAND ITS CAPABILITY AND APPLICABILITY 69.6
3. THOROUGHLY UNDERSTAND ITS CAPABILITY AND APPLICABILITY 4.8

IMPEDIMENTS TO APPLYING N/C

1-58. HAVE YOU MADE A FORMAL EVALUATION OF THE APPLICABILITY OF N/C TO YOUR OPERATIONS?
1. YES ☐ 28.4 2. NO ☐ 71.6

1-59. CONCERNING THE APPLICABILITY OF N/C TO YOUR OPERATIONS DO YOU FEEL (CIRCLE ONE)
1. IT IS APPLICABLE 23.8 2. IT IS NOT APPLICABLE 52.7 3. UNSURE-NEED MORE INFORMATION 23.5

IF ANSWER TO 1-59. IS "2. IT IS NOT APPLICABLE" WHY? (CIRCLE ALL THAT APPLY)

1-60. EXCESSIVE COST 25.1
1-61. EXCESSIVE RISK 2.7
1-62. PRODUCT IS MASS PRODUCED 11.5
1-63. TYPE OF PRODUCT 31.4
1-64. PARTS ARE NOT COMPLEX 24.0
1-65. PARTS USUALLY REQUIRE SINGLE SET UP 20.5
1-66. FEEDS AND SPEEDS REMAIN CONSTANT 16.4
1-67. PART DESIGN RARELY CHANGES 15.3
1-68. OTHER (SPECIFY) 6.3

WHAT KIND OF ADDITIONAL INFORMATION CONCERNING N/C WOULD BE HELPFUL TO YOU (CIRCLE ALL THAT APPLY)

1-69. A METHOD FOR SURVEYING YOUR PLANT TO DETERMINE N/C APPLICABILITY 27.6
1-70. COST JUSTIFICATION INFORMATION 43.4
2-1. N/C MAINTENANCE PROBLEMS AND THEIR SOLUTIONS 18.0
2-2. N/C PARTS PROGRAMMING 16.7
2-3. N/C PERSONNEL QUALIFICATIONS AND SELECTION 20.5
2-4. N/C SYSTEMS SELECTION 16.1
2-5. N/C EQUIPMENT SELECTION 19.1
2-6. OTHER (SPECIFY) 2.2

REASONS PAST AND EXISTING EFFORTS FAILED TO CONVINCE YOU TO USE N/C TECHNOLOGY

IF YOU HAVE BEEN EXPOSED TO INFORMATION CONCERNING N/C AND ITS APPLICABILITY TO YOUR OPERATIONS AND YOU HAVE DECIDED NOT TO USE N/C, WHICH OF THE FOLLOWING FACTORS DESCRIBES THE REASON(S) FOR YOUR DECISION? (CIRCLE ALL THAT APPLY)

2-7. HAVE NOT MADE AN ANALYSIS OF OUR OPERATIONS 17.5
2-8. INSUFFICIENT TIME TO STUDY THE PROBLEM 11.2
2-9. NOT APPLICABLE TO OUR OPERATIONS BASED ON ANALYSIS 30.9
2-10. INADEQUATE RETURN ON INVESTMENT 30.6

2-11. UNABLE TO RAISE THE REQUIRED CAPITAL 13.4

2-12. INVESTMENT IS TOO RISKY 6.6

2-13. MAINTENANCE SUPPORT IS DOUBTFUL 12.0

2-14. PART PROGRAMMING SUPPORT IS DOUBTFUL 6.8

2-15. PROBLEMS IN RETRAINING EMPLOYEES 8.5

2-16. EMPLOYEES CONCERNED ABOUT JOB SECURITY 1.1

2-17. OTHER (SPECIFY)_____ 6.8

BECOMING FAMILIAR WITH N/C

WHICH OF THE FOLLOWING MEANS WOULD YOU LIKE TO USE FOR MEMBERS OF YOUR ORGANIZATION INCLUDING YOURSELF TO BECOME MORE FAMILIAR WITH N/C TECHNOLOGY? (CIRCLE ALL THAT APPLY)

2-18. NONE 20.8

2-19. ATTEND SHORT (2-5 DAYS) COURSES OR SEMINARS 18.3

2-20. ATTEND ''HANDS-ON'' WORKSHOP IN N/C MACHINE OPERATION 24.6

2-21. ATTEND ''HANDS-ON'' WORKSHOP IN N/C PART PROGRAMMING 19.7

2-22. ATTEND ''HANDS-ON'' WORKSHOP IN N/C MAINTENANCE 16.1

2-23. ATTEND EVENING COURSES 12.0

2-24. READ BASIC N/C LITERATURE 33.6

2-25. READ CASE HISTORIES 12.0

2-26. VISIT OTHER PLANTS (SIMILAR TO YOURS) WHO USE N/C 32.5

2-27. VISIT MACHINE TOOL BUILDERS 9.0

2-28. JOIN A TECHNICAL SOCIETY 2.5

2-29. PARTICIPATE IN A ''TRIAL-RUN'' WITH YOUR DRAWINGS BEING USED TO DEVELOP N/C PART PROGRAMS WHICH ARE USED TO MACHINE YOUR MATERIAL TO PRODUCE YOUR PARTS. 19.1

2-30. OTHER (SPECIFY) 2.5

USING N/C - YOUR ANSWERS TO THESE QUESTIONS ARE EXTREMELY IMPORTANT IN HELPING TO OVERCOME BARRIERS TO APPLYING N/C TECHNOLOGY

WHICH OF THE FOLLOWING WOULD HAVE TO TAKE PLACE BEFORE YOU USE N/C OR SIGNIFICANTLY INCREASE ITS USE IN YOUR PLANT? (CIRCLE ALL THAT APPLY)

2-31. SEVERAL N/C MACHINE TOOL BUILDERS VISIT OUR PLANT AND MAKE PROPOSALS 12.8

2-32. OUR STAFF MAKES AN ECONOMIC JUSTIFICATION STUDY 40.2

2-33. A CONSULTANT REVIEWS OUR OPERATIONS AND ADVISES US 15.6

2-34. A SAMPLE RUN OF OUR PARTS PROGRAMMED FOR AND RUN ON AN N/C MACHINE SO WE WOULD HAVE ''HARD'' DATA ON ''SET-UP'' AND ''RUN'' TIMES, TOOLING COSTS, PROGRAMMING COSTS, ETC. 29.2

2-35. TRAINING FOR OUR PERSONNEL IN AN OVERVIEW OF N/C 21.3

2.36. TRAINING FOR OUR PERSONNEL IN N/C MAINTENANCE 17.8

2.37. TRAINING FOR OUR PERSONNEL IN PART PROGRAMMING 16.7

2.38. RECEIPT OF EVIDENCE THAT N/C MAINTENANCE SUPPORT EXISTS 9.8

2.39. RECEIPT OF EVIDENCE THAT N/C PART PROGRAMMING SUPPORT EXISTS 9.0

2.40. GOVERNMENT TAX INCENTIVES FOR INVESTING IN N/C EQUIPMENT 20.5

2.41. LOWER PRICES FOR N/C EQUIPMENT 35.5

FORECAST

2.42. WITHIN HOW MANY YEARS DO YOU FEEL YOUR PLANT WILL HAVE AT LEAST ONE PIECE OF N/C EQUIPMENT? (CIRCLE ONE)
1. NEVER 30.1 2. WITHIN 2 YRS. 14.3 3. 2-5 YRS. 29.8 4. 5-10 YRS. 16.5 5. OVER 10 YRS. 9.3

2.43. WITHIN HOW MANY YEARS DO YOU FEEL THAT AT LEAST 10% OF THE EQUIPMENT IN YOUR PLANT WILL BE N/C EQUIPMENT? (CIRCLE ONE)
1. NEVER 41.9 2. WITHIN 2 YRS. 1.3 3. 2-5 YRS. 12.5 4. 5-10 YRS. 20.1 5. OVER 10 YRS. 24.1

WE ATTEMPTED TO SEND THIS QUESTIONNAIRE TO ONLY THOSE ORGANIZATIONS WHO DO NOT HAVE N/C EQUIPMENT. HOWEVER, IF YOU DO HAVE N/C EQUIPMENT WE WOULD APPRECIATE YOUR ANSWERS TO THE FOLLOWING QUESTIONS.

2.44. HOW MANY N/C TOOLS ARE AT THIS LOCATION? (CIRCLE ONE)
1. 1-2 – 2. 3-5 – 3. 5-10 – 4. OVER 10 –

2.45. ARE YOU SATISFIED WITH YOUR N/C EQUIPMENT? 1. YES ☐ 2. NO ☐ –

WHY DID YOU PURCHASE N/C EQUIPMENT? (CIRCLE ALL THAT APPLY)

2.46. TO REDUCE MANUFACTURING COSTS –

2.47. TO REDUCE TOOLING COSTS –

2.48. TO MEET TOLERANCES (ACCURACY AND REPEATABILITY) –

2.49. TO IMPROVE PRODUCTION CONTROL –

2.50. SHORTAGE OF SKILLED LABOR –

2.51. NEED TO REDUCE LEAD TIME –

2.52. OTHER. SPECIFY –

2.53. DO YOU PLAN TO PURCHASE ADDITIONAL N/C EQUIPMENT? 1. YES ☐ 2. NO ☐ –

IT IS NOT NECESSARY TO IDENTIFY YOU OR YOUR COMPANY IN RETURNING THIS QUESTIONNAIRE. HOWEVER, WE WOULD LIKE TO TELEPHONE SEVERAL INDIVIDUALS WHO HAVE COMPLETED THIS QUESTIONNAIRE TO DISCUSS THESE ANSWERS IN GREATER DETAIL. IF YOU AGREE TO THIS POSSIBILITY, PLEASE WRITE YOUR NAME AND TELEPHONE NUMBER BELOW.

2.54. _____
NAME AREA CODE TELEPHONE NUMBER

(All Responses are Given in %)

MANUFACTURING SHOP SURVEY

SUMMARY OF RESPONSES FROM 146 COMPANIES

PLANT DESCRIPTION

1. 1. IN WHAT STATE IS YOUR PLANT LOCATED?

CA	11.6	MA	7.5	NY	8.2	TX	4.8
CT	2.1	MI	14.4	OH	13.7	WI	6.2
IL	9.6	MN	4.8	PA	8.9	Unidentified	2.0
IN	4.1	NJ	2.1	SC	-		

1. 2. HOW MANY PEOPLE ARE EMPLOYED AT THIS LOCATION? (CIRCLE ONE)

1. UNDER 25	2. 25-50	3. 50-100	4. 100-200	5. OVER 200
6.2	18.5	21.9	32.2	21.2

1. 3. WHAT IS THE APPROXIMATE ANNUAL SALES DOLLAR VALUE OF PRODUCT PRODUCED AT THIS LOCATION? (CIRCLE ONE)

1. UNDER 1 MILLION	13.8	3. 2-5 MILLION	29.0	5. 10-15 MILLION	11.6
2. 1-2 MILLION	13.0	4. 5-10 MILLION	23.9	6. OVER 15 MILLION	8.7

1. 4. ARE MOST OF THE ITEMS MANUFACTURED AT THIS LOCATION DESIGNED BY YOUR COMPANY? 1. YES ☐ 2. NO ☐
71.7 28.3

1. 5. IS THIS PLANT A DIVISION OR SUBSIDIARY OF A CORPORATION OR ONE OF A GROUP OF PLANTS IN THE SAME COMPANY? 1. YES ☐ 2. NO ☐
48.6 51.4

1. 6. WHAT IS THE APPROXIMATE NUMBER OF MACHINE TOOLS AT THIS LOCATION? (CIRCLE ONE)

1. UNDER 10	2. 10-25	3. 25-50	4. 50-100	5. OVER 100
6.9	20.0	32.4	28.3	12.4

1. 7. INTO WHAT AGE CATEGORY DO MOST OF THESE MACHINES FALL? (CIRCLE ONE)

1. UNDER 5 YRS.	2. 5-10 YRS.	3. 10-15 YRS.	4. 15-20 YRS.	5. OVER 20 YRS.
7.5	32.2	30.8	17.1	12.3

1. 8. WHAT PROPORTION OF MACHINE TOOL MAINTENANCE IS PERFORMED BY YOUR OWN EMPLOYEES? (CIRCLE ONE)

1. ALL	2. 75%-100%	3. 50%-75%	4. 25%-50%	5. 1-25%	6. NONE
23.3	52.7	14.4	5.5	3.4	.7

1. 9. IS THERE A COMPUTER OR COMPUTER TERMINAL IN YOUR PLANT? 1. YES ☐ 2. NO ☐
73.8 26.2

1.10. DO YOU USE A COMPUTER OR DATA PROCESSING SERVICE BUREAU? 1. YES 2. NO
47.5 52.5

WHAT TYPES OF MANUFACTURING COMPUTER APPLICATIONS DO YOU HAVE? (CIRCLE ALL THAT APPLY)

1.11.	NONE	16.4	1.15.	QUALITY CONTROL	8.9
1.12.	PRODUCTION CONTROL	53.4	1.16.	ROUTING	24.0
1.13.	INVENTORY CONTROL	52.1	1.17.	OTHER	37.0
1.14.	TIME STANDARDS	34.2		SPECIFY	Primarily N/C Applications

N/C INFORMATION

DO YOU KNOW THE MEANINGS OF THE FOLLOWING TERMS?

1.18.	NUMERICAL CONTROL	1. YES ☐ 100.0	2. NO ☐	1.24.	RNC	1. YES ☐ 24.7	2. NO ☐
1.19.	PART PROGRAMMING	1. YES ☐ 93.2	2. NO ☐	1.25.	APT	1. YES ☐ 52.1	2. NO ☐
1.20.	PUNCHED TAPE	1. YES ☐ 100.0	2. NO ☐	1.26.	MULTI AXIS	1. YES ☐ 90.4	2. NO ☐
1.21.	GROUP TECHNOLOGY	1. YES ☐ 48.6	2. NO ☐	1.27.	BILATERAL DRIVER	1. YES ☐ 32.2	2. NO ☐
1.22.	CNC	1. YES ☐ 82.9	2. NO ☐	1.28.	MACHINE CONTROL	1. YES ☐ 88.4	2. NO ☐
1.23.	DNC	1. YES ☐ 67.1	2. NO ☐	1.29.	LINEAR INTERPOLATION	1. YES ☐ 80.6	2. NO ☐

MANUFACTURING ENVIRONMENT

1-30. DO MORE THAN 25% OF YOUR PARTS CONTAIN STRAIGHT LINES, CONCENTRIC CIRCLES AND HOLES?
1. YES ☐ 2. NO ☐
93.8

1-31. DO MORE THAN 25% OF YOUR PARTS CONTAIN COMPOUND ANGLES?
1. YES ☐ 2. NO ☐
30.1

1-32. DO MORE THAN 25% OF YOUR PARTS CONTAIN ECCENTRIC CIRCLES?
1. YES ☐ 2. NO ☐
13.0

1-33. DO MORE THAN 25% OF YOUR PARTS CONTAIN CONTOURS THAT ARE NOT STRAIGHT LINES OR CIRCLES?
1. YES ☐ 2. NO ☐
35.6

1-34. HOW LONG DOES THE AVERAGE JOB SET-UP TAKE IN YOUR PLANT? (CIRCLE ONE)
1. UNDER 1 HOUR 31.5 2. 1-3 HOURS 41.8 3. 3-5 HOURS 19.2 4. 5-8 HOURS 4.8 5. OVER 8 HOURS 2.7

1-35. WHAT IS THE MOST TYPICAL LOT SIZE IN YOUR PLANT? (CIRCLE ONE)
1. UNDER 10 PCS 21.2 3. 25-50 PCS 11.6 5. 100-500 PCS 22.6
2. 10-25 PCS 11.0 4. 50-100 PCS 20.5 6. OVER 500 PCS 13.0

1-36. DO MORE THAN 25% OF YOUR PARTS HAVE DIMENSIONS WITH TOLERANCES GREATER THAN ± .005''? 1. YES ☐ 2. NO ☐
47.2

1-37. DO MORE THAN 25% OF YOUR PARTS HAVE DIMENSIONS WITH TOLERANCES BETWEEN ± .001'' AND ± .005''? 1. YES ☐ 2. NO ☐
78.5

1-38. DO MORE THAN 25% OF YOUR PARTS HAVE DIMENSIONS WITH TOLERANCES LESS THAN .001?
1. YES ☐ 2. NO ☐
23.6

1-39. DO YOU PRODUCE PARTS WITH CONTOURS DEFINED BY MATHEMATICAL EQUATIONS? 1. YES ☐ 2. NO ☐
44.5

1-40. WITHIN A SINGLE SET-UP DO MORE THAN 25% OF YOUR PARTS REQUIRE MORE THAN 1 CHANGE IN FEED OR SPEED? 1. YES ☐ 2. NO ☐
69.0

1-41. WITHIN A SINGLE SET-UP DO MORE THAN 25% OF YOUR PARTS REQUIRE MORE THAN 3 CHANGES IN FEED OR SPEED? 1. YES ☐ 2. NO ☐
47.6

1-42. WITHIN A SINGLE SET-UP DO MORE THAN 25% OF YOUR PARTS REQUIRE MORE THAN 5 CHANGES IN FEED OR SPEED? 1. YES ☐ 2. NO ☐
24.1

1-43. HOW OFTEN IS THE DESIGN OF THE TYPICAL PART MANUFACTURED IN YOUR PLANT CHANGED? (CIRCLE ONE)
1. NEVER 24.1 3. 2-5 TIMES PER YEAR 20.6 5. OVER 10 TIMES PER YEAR 7.1
2. ONCE PER YEAR 46.1 4. 5-10 TIMES PER YEAR 2.1

1-44. WHAT PERCENTAGE OF THE PARTS MANUFACTURED IN YOUR PLANT CAN BE GROUPED INTO FAMILIES BECAUSE OF SIMILAR SHAPES AND PROCESSING? (CIRCLE ONE)
1. NONE 5.6 3. 10%-25% 25.4 5. OVER 50% 26.8
2. 1%-10% 19.7 4. 25%-50% 22.5

1-45. HOW MANY MACHINING ''SET-UPS'' DOES THE AVERAGE PART YOU MANUFACTURE REQUIRE? (CIRCLE ONE)
1. ONE 8.4 2. 2-5 67.8 3. 6-10 16.8 4. OVER 10 7.0

1-46. WHAT PERCENTAGE OF THE PARTS YOU MACHINE REQUIRE SPECIAL JIGS AND FIXTURES? (CIRCLE ONE)
1. NONE 4.1 2. 1%-10% 25.5 3. 10%-25% 26.2 4. 25%-50% 18.6 5. OVER 50% 25.5

1-47. WHAT PERCENTAGE OF THE PARTS ENTERING YOUR MACHINE SHOP ARE PARTS YOU HAVE NOT MACHINED BEFORE? (CIRCLE ONE)
1. NONE 4.9 2. 1%-10% 43.7 3. 10%-25% 20.4 4. 25%-50% 9.9 5. OVER 50% 21.1

SOURCE OF N/C INFORMATION

HOW DID YOU ACQUIRE YOUR KNOWLEDGE OF N/C? (CIRCLE ALL THAT APPLY)

1-48. NO KNOWLEDGE 2.7
1-49. COURSES & SEMINARS 56.2
1-50. TRADE JOURNALS 69.2
1-51. PRODUCT LITERATURE 71.2
1-52. MACHINERY SALESMEN 56.8
1-53. TOOL SHOWS 67.1
1-54. TECHNICAL MEETINGS 34.2
1-55. OTHER (SPECIFY) 27.4 (Primarily Practical Experience)

1-56. WRITE DOWN THE NUMBER OF THE ANSWER 1-48 THROUGH 1-55 ABOVE THAT CONTRIBUTED MOST SIGNIFICANTLY TO YOUR KNOWLEDGE OF N/C. See Figure 4

1-57. WHICH OF THE FOLLOWING APPLIES TO YOU? (CIRCLE ONE)
1. UNFAMILIAR WITH N/C 2.8
2. GENERALLY UNDERSTAND ITS CAPABILITY AND APPLICABILITY 61.8
3. THOROUGHLY UNDERSTAND ITS CAPABILITY AND APPLICABILITY 35.4

IMPEDIMENTS TO APPLYING N/C

1-58. HAVE YOU MADE A FORMAL EVALUATION OF THE APPLICABILITY OF N/C TO YOUR OPERATIONS?
1. YES ☐ 73.9 2. NO ☐ 26.1

1-59. CONCERNING THE APPLICABILITY OF N/C TO YOUR OPERATIONS DO YOU FEEL (CIRCLE ONE)
1. IT IS APPLICABLE 88.0 2. IT IS NOT APPLICABLE 8.5 3. UNSURE-NEED MORE INFORMATION 3.5

IF ANSWER TO 1-59. IS "2. IT IS NOT APPLICABLE" WHY? (CIRCLE ALL THAT APPLY)

1-60. EXCESSIVE COST 5.5
1-61. EXCESSIVE RISK .7
1-62. PRODUCT IS MASS PRODUCED 2.1
1-63. TYPE OF PRODUCT 4.8
1-64. PARTS ARE NOT COMPLEX 2.7
1-65. PARTS USUALLY REQUIRE SINGLE SET UP 3.4
1-66. FEEDS AND SPEEDS REMAIN CONSTANT 1.4
1-67. PART DESIGN RARELY CHANGES 3.4
1-68. OTHER (SPECIFY) 1.4

WHAT KIND OF ADDITIONAL INFORMATION CONCERNING N/C WOULD BE HELPFUL TO YOU (CIRCLE ALL THAT APPLY)

1-69. A METHOD FOR SURVEYING YOUR PLANT TO DETERMINE N/C APPLICABILITY 17.1
1-70. COST JUSTIFICATION INFORMATION 41.8
2-1. N/C MAINTENANCE PROBLEMS AND THEIR SOLUTIONS 34.9
2-2. N/C PARTS PROGRAMMING 17.1
2-3. N/C PERSONNEL QUALIFICATIONS AND SELECTION 30.8
2-4. N/C SYSTEMS SELECTION 17.1
2-5. N/C EQUIPMENT SELECTION 22.6
2-6. OTHER (SPECIFY) 3.4

REASONS PAST AND EXISTING EFFORTS FAILED TO CONVINCE YOU TO USE N/C TECHNOLOGY

IF YOU HAVE BEEN EXPOSED TO INFORMATION CONCERNING N/C AND ITS APPLICABILITY TO YOUR OPERATIONS AND YOU HAVE DECIDED NOT TO USE N/C, WHICH OF THE FOLLOWING FACTORS DESCRIBES THE REASON(S) FOR YOUR DECISION? (CIRCLE ALL THAT APPLY)

2-7. HAVE NOT MADE AN ANALYSIS OF OUR OPERATIONS 2.1
2-8. INSUFFICIENT TIME TO STUDY THE PROBLEM 5.5
2-9. NOT APPLICABLE TO OUR OPERATIONS BASED ON ANALYSIS 4.8
2-10. INADEQUATE RETURN ON INVESTMENT 13.0

2-11.	UNABLE TO RAISE THE REQUIRED CAPITAL	8.2
2-12.	INVESTMENT IS TOO RISKY	4.8
2-13.	MAINTENANCE SUPPORT IS DOUBTFUL	5.5
2-14.	PART PROGRAMMING SUPPORT IS DOUBTFUL	2.1
2-15.	PROBLEMS IN RETRAINING EMPLOYEES	2.1
2-16.	EMPLOYEES CONCERNED ABOUT JOB SECURITY	2.1
2-17.	OTHER (SPECIFY)_____	7.5

BECOMING FAMILIAR WITH N/C

WHICH OF THE FOLLOWING MEANS WOULD YOU LIKE TO USE FOR MEMBERS OF YOUR ORGANIZATION INCLUDING YOURSELF TO BECOME MORE FAMILIAR WITH N/C TECHNOLOGY? (CIRCLE ALL THAT APPLY)

2-18.	NONE	6.8
2-19.	ATTEND SHORT (2-5 DAYS) COURSES OR SEMINARS	34.9
2-20.	ATTEND ''HANDS-ON'' WORKSHOP IN N/C MACHINE OPERATION	41.8
2-21.	ATTEND ''HANDS-ON'' WORKSHOP IN N/C PART PROGRAMMING	38.4
2-22.	ATTEND ''HANDS-ON'' WORKSHOP IN N/C MAINTENANCE	34.9
2-23.	ATTEND EVENING COURSES	15.1
2-24.	READ BASIC N/C LITERATURE	24.0
2-25.	READ CASE HISTORIES	9.6
2-26.	VISIT OTHER PLANTS (SIMILAR TO YOURS) WHO USE N/C	37.7
2-27.	VISIT MACHINE TOOL BUILDERS	24.7
2-28.	JOIN A TECHNICAL SOCIETY	10.3
2-29.	PARTICIPATE IN A ''TRIAL-RUN'' WITH YOUR DRAWINGS BEING USED TO DEVELOP N/C PART PROGRAMS WHICH ARE USED TO MACHINE YOUR MATERIAL TO PRODUCE YOUR PARTS.	32.2
2-30.	OTHER (SPECIFY) _____	1.4

USING N/C - YOUR ANSWERS TO THESE QUESTIONS ARE EXTREMELY IMPORTANT IN HELPING TO OVERCOME BARRIERS TO APPLYING N/C TECHNOLOGY

WHICH OF THE FOLLOWING WOULD HAVE TO TAKE PLACE BEFORE YOU USE N/C OR SIGNIFICANTLY INCREASE ITS USE IN YOUR PLANT? (CIRCLE ALL THAT APPLY)

2-31.	SEVERAL N/C MACHINE TOOL BUILDERS VISIT OUR PLANT AND MAKE PROPOSALS	15.1
2-32.	OUR STAFF MAKES AN ECONOMIC JUSTIFICATION STUDY	43.2
2-33.	A CONSULTANT REVIEWS OUR OPERATIONS AND ADVISES US	7.5
2-34.	A SAMPLE RUN OF OUR PARTS PROGRAMMED FOR AND RUN ON AN N/C MACHINE SO WE WOULD HAVE ''HARD'' DATA ON ''SET-UP'' AND ''RUN'' TIMES, TOOLING COSTS, PROGRAMMING COSTS, ETC.	29.5
2-35.	TRAINING FOR OUR PERSONNEL IN AN OVERVIEW OF N/C	17.1

2-36. TRAINING FOR OUR PERSONNEL IN N/C MAINTENANCE 19.2

2-37. TRAINING FOR OUR PERSONNEL IN PART PROGRAMMING 19.9

2-38. RECEIPT OF EVIDENCE THAT N/C MAINTENANCE SUPPORT EXISTS 13.7

2-39. RECEIPT OF EVIDENCE THAT N/C PART PROGRAMMING SUPPORT EXISTS 4.8

2-40. GOVERNMENT TAX INCENTIVES FOR INVESTING IN N/C EQUIPMENT 37.7

2-41. LOWER PRICES FOR N/C EQUIPMENT 40.4

FORECAST

2-42. WITHIN HOW MANY YEARS DO YOU FEEL YOUR PLANT WILL HAVE AT LEAST ONE PIECE OF N/C EQUIPMENT? (CIRCLE ONE)

1. NEVER 9.1 2. WITHIN 2 YRS. 70.5 3. 2-5 YRS. 11.4 4. 5-10 YRS. 4,5 5. OVER 10 YRS. 4.5

2-43. WITHIN HOW MANY YEARS DO YOU FEEL THAT AT LEAST 10% OF THE EQUIPMENT IN YOUR PLANT WILL BE N/C EQUIPMENT? (CIRCLE ONE)

1. NEVER 14.0 2. WITHIN 2 YRS. 19.0 3. 2-5 YRS. 29,0 4. 5-10 YRS. 30.0 5. OVER 10 YRS. 8.0

WE ATTEMPTED TO SEND THIS QUESTIONNAIRE TO ONLY THOSE ORGANIZATIONS WHO DO NOT HAVE N/C EQUIPMENT. HOWEVER, IF YOU DO HAVE N/C EQUIPMENT WE WOULD APPRECIATE YOUR ANSWERS TO THE FOLLOWING QUESTIONS.

2-44. HOW MANY N/C TOOLS ARE AT THIS LOCATION? (CIRCLE ONE)

1. 1-2 51.4 2. 3-5 22.6 3. 5-10 16.4 4. OVER 10 9,6

2-45. ARE YOU SATISFIED WITH YOUR N/C EQUIPMENT? 1. YES ☐ 2. NO ☐

86.3 13.7

WHY DID YOU PURCHASE N/C EQUIPMENT? (CIRCLE ALL THAT APPLY)

2-46. TO REDUCE MANUFACTURING COSTS 87.0

2-47. TO REDUCE TOOLING COSTS 43.2

2-48. TO MEET TOLERANCES (ACCURACY AND REPEATABILITY) 54.8

2-49. TO IMPROVE PRODUCTION CONTROL 47.3

2-50. SHORTAGE OF SKILLED LABOR 39.0

2-51. NEED TO REDUCE LEAD TIME 54.1

2-52. OTHER. SPECIFY _____ 13.7

2-53. DO YOU PLAN TO PURCHASE ADDITIONAL N/C EQUIPMENT? 1. YES ☐ 2. NO ☐

84.9 15.1

IT IS NOT NECESSARY TO IDENTIFY YOU OR YOUR COMPANY IN RETURNING THIS QUESTIONNAIRE. HOWEVER, WE WOULD LIKE TO TELEPHONE SEVERAL INDIVIDUALS WHO HAVE COMPLETED THIS QUESTIONNAIRE TO DISCUSS THESE ANSWERS IN GREATER DETAIL. IF YOU AGREE TO THIS POSSIBILITY, PLEASE WRITE YOUR NAME AND TELEPHONE NUMBER BELOW.

2-54. _____

NAME AREA CODE TELEPHONE NUMBER